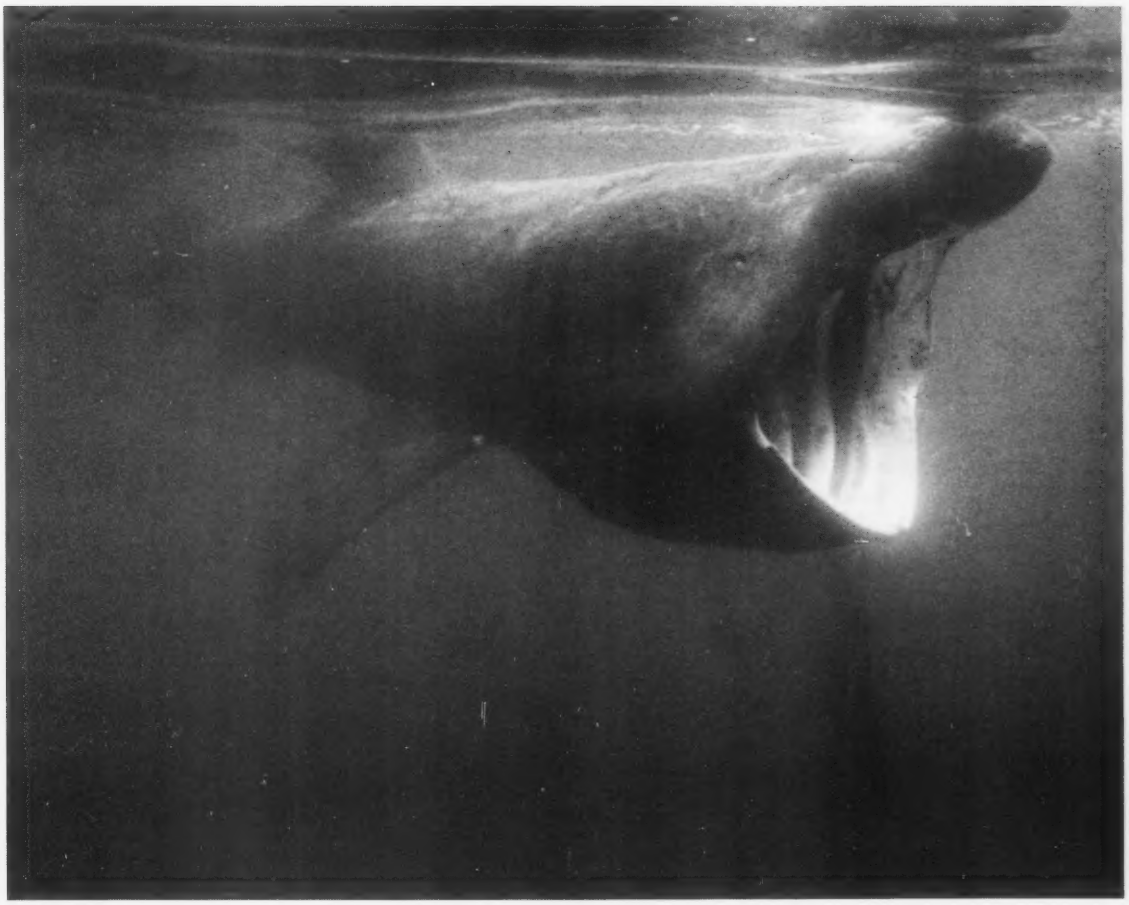
Marine Fisheries REVIEW

Vol. 52, No. 2
1990

National Oceanic and Atmospheric Administration • National Marine Fisheries Service



The Basking Shark

Marine Fisheries REVIEW

On the cover: A 20-foot basking shark feeds in the Santa Barbara Channel, Calif. Photo copyright by Chuck Davis, 1324 W. 19th St., San Pedro, CA 90732.

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The *Marine Fisheries Review* (ISSN 0090-1830) is published quarterly by the Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115. Single copies and annual subscriptions are sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402: Single copy, $5.50 domestic, $6.88 foreign; annual subscription, $9.00 domestic; $11.25 foreign.

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Application of the Leslie Model to Commercial Catch and Effort of the Slipper Lobster, *Scyllarides squammosus*, Fishery in the Northwestern Hawaiian Islands

RAYMOND P. CLARKE and STACEY S. YOSHIMOTO

ABSTRACT—Commercial catch and effort data were fit to the Leslie model to estimate preexploitation abundance and the catchability coefficient of slipper lobster, Scyllarides squammosus, *in the Northwestern Hawaiian Islands (NWHI). A single vessel fished for 34 consecutive days in the vicinity of Laysan Island and caught 126,127 total slipper lobster in 36,170 trap hauls. Adjusted catch of legal slipper lobster dropped from a high of 3.70 to 1.16 lobster per trap haul. Preexploitation abundance at Laysan Island was an estimated 204,000 legal slipper lobster, which was extrapolated to yield an estimate of 1.2 × 10^6 to 3.8 × 10^6 lobster for the entire NWHI slipper lobster fishery.*

Introduction

Intensive fishing experiments are widely accepted in fishery literature as a relatively easy way to estimate the catchability coefficients of exploitable stocks. This information can be used to determine absolute estimates of exploitable stock, as compared with relative estimates (i.e., catch per unit effort (CPUE)). The two most widely accepted methods for obtaining these estimates are the Leslie and Delury models, which have been explored in considerable detail (Ricker, 1975; Crittenden, 1983; Schnute, 1983; Polovina, 1986). These models have several assumptions: The population fished is isolated or closed, fishing removals account for all changes in stock size, and catchability is constant (although as shown by Polovina (1986), this assumption is not restrictive). Substantial fishing effort exerted over a short timespan should reveal that the slope of a linear regression of CPUE on cumulative catch (Leslie and Davis, 1939) or LOG (CPUE) on LOG cumulative effort (Delury, 1947) is negative. In the Leslie model, the x-intercept reveals virgin stock size (K), the y-intercept shows initial CPUE at virgin biomass, and the absolute value of the slope of the line is the catchability coefficient (q).

Most of the reported studies using the Leslie model have involved laboratory experiments, fieldwork in ponds, or, more recently, field studies using research vessels at sea (Polovina, 1986; Ralston, 1986). While field studies offer many benefits, they may have operational and financial constraints resulting in relatively small amounts of effort being expended. One way to overcome this problem is to use commercial operations to fish marine reserves or restricted areas. If a commercial vessel fishes in a previously unexploited area for a reasonable amount of time, then removals from the fished stock will be great enough to cause a significant decline in CPUE. Such a situation presented itself in June 1986, when a commercial lobster vessel fished for slipper lobster, *Scyllarides squammosus*, at Laysan Island in the Northwestern Hawaiian Islands (NWHI). Laysan Island, with its associated bank, is a designated reserve for the spiny lobster, *Panulirus marginatus*, and had no prior history of slipper lobster exploitation. The vessel fished for 34 consecutive days and caught over 126,000 slipper lobster. As required by law, the vessel kept daily catch and effort logs for spiny lobster. The same data, along with additional information on trap placement, were maintained for slipper lobster. This otherwise confidential information was released by the vessel owner and skipper to the authors for analysis.

This paper presents a Leslie model modified for the use of commercial fisheries data to estimate catchability and preexploitation abundance of slipper lobster at Laysan Island. This species is distributed throughout the Indo-Pacific region north of Clipperton Island (Williams, 1986). A commercial slipper lobster fishery centered in the NWHI has recently emerged in conjunction with that for spiny lobster. In 1986, over 480 metric tons (t) of slipper lobster, valued at $2.3 million were landed by the NWHI lobster fleet (Clarke[1]). Until this time, estimates of catchability have been made by production models that treat spiny and slipper lobsters as one stock. Here, an independent estimate of slipper lobster alone will be presented, along with an estimate of preexploitation stock size at Laysan Island that may be applied to the entire NWHI lobster fishery.

Methods

The vessel fished between 11 June and 14 July 1986 in the vicinity of Laysan Island and its associated bank, which is

The authors are with the Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, 2570 Dole Street, Honolulu, HI 96822-2396.

[1]Clarke, R. P. 1989. Annual report of the 1988 western Pacific lobster fishery. Honolulu Lab., Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-89-5, 28 p.

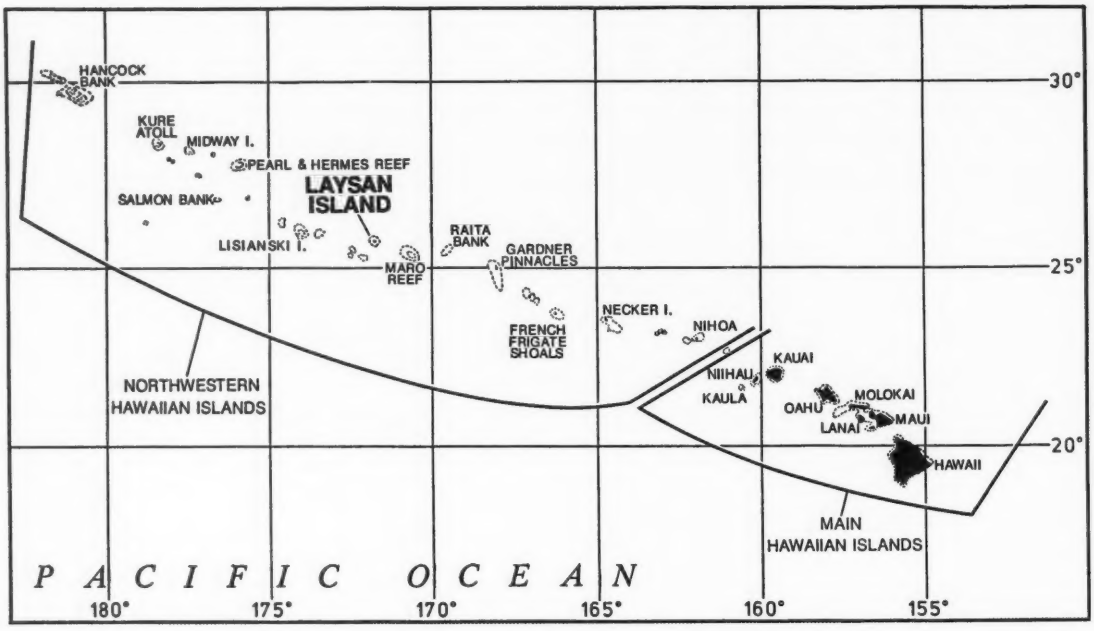


Figure 1.—The Northwestern Hawaiian Islands, including Laysan Island.

henceforth referred to as Laysan bank. Laysan Island is a small, uninhabited, predominantly coral-sand island, 2.8 km long and 1.7 km wide. It is located at lat. 25°42′N and long. 171°44′W, at the midpoint of the NWHI (Fig. 1), and is about 1,350 km northwest of Honolulu. The bank includes 482.2 km^2 (horizontal planar area) of potential habitat for lobster at the 20-200 m depths (WPRFMC[2]). Slipper lobster are known by NWHI fishermen to concentrate in areas at the 40-120 m depths.

The daily operations of the vessel involved deploying and hauling 1,125 Fathom Plus[3] lobster traps set in strings spaced at 30 m intervals. The traps are of black polyethylene construction (overall dimensions, 104 × 81 × 46 cm) and have two tapered entrance funnels (30 cm exterior diameter; 50 × 50 mm mesh). They were fished in 7 strings of about 160 traps each and baited with Pacific mackerel, *Scomber japonicus*. Strings were soaked overnight and retrieved the following day; therefore, the standard unit of effort is the trap-haul. The northwest corner of Laysan bank was initially explored for lobster concentrations at 30-120 m depths; however, some traps were set as deep as 200 m.

In 1986, there were no Federally mandated laws for slipper lobster. However, because of market conditions, the vessel retained only those slipper lobster that were free of eggs and had a tail size larger than 85 g (3 ounces), returning all others to the water. The vessel counted retained lobster but estimated the egg-bearing lobster and those below the 85 g minimum size. Since that time, a minimum size regulation of 56 mm tail width has been applied to the slipper lobster (WPRFMC[4]). The 56 mm tail width closely approximates the 85 g slipper lobster tail size (National Marine Fisheries Service (NMFS) unpubl. data); therefore, retained lobster can be viewed as legal lobster, those below 85 g as sublegal, and egg-bearing females as berried.

The general Leslie model is written as

$$U\langle t\rangle = q(K - CC\langle t\rangle); \quad (1)$$

where $U\langle t\rangle$ is the CPUE at the time t, q is the catchability coefficient, K is pre-exploitation stock size, and $CC\langle t\rangle$ is the cumulative catch at time t. If slipper lobster are partitioned into legal, sub-

[2]Western Pacific Regional Fishery Management Council (WPRFMC). 1983. Spiny lobster fishery management plan. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, 213 p.

[3]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[4]Western Pacific Regional Fishery Management (WPRFMC). 1987. Crustacean fishery management plan amendment 5. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, 58 p.

Table 1.—Summary of catch and effort data from a commercial vessel fishing for slipper lobster at Laysan bank, Hawaii, 11 June through 14 July 1986. Legal lobster have tails >85 g, sublegal are <85 g, and berried are egg-bearing females. Catch per unit effort (CPUE) equals number of legal lobster per trap-haul.

	Lobster catch				Adjusted cumulative	Daily			Lobster catch				Adjusted cumulative	Daily	
Day	Legal	Sublegal	Berried	Total	legal catch	effort	CPUE	Day	Legal	Sublegal	Berried	Total	legal catch	effort	CPUE
1	2,133	1,000	1,000	4,133	1,066.5	1,125	1.896	19	2,362	425	260	3,047	51,393.0	1,125	2.099
2	1,675	450	600	2,725	2,970.5	1,125	1.488	20	2,142	400	300	2,842	53,645.0	1,125	1.904
3	2,976	1,785	1,050	5,811	5,296.0	1,125	2.645	21	1,955	290	235	2,480	55,693.5	1,125	1.737
4	3,788	1,850	1,580	7,218	8,678.0	1,125	3.367	22	1,924	210	135	2,269	57,633.0	1,125	1.710
5	2,883	1,750	1,150	5,783	12,013.5	1,125	2.562	23	2,332	320	280	2,932	59,761.0	1,125	2.072
6	2,430	1,470	980	4,880	14,670.0	1,125	2.160	24	1,216	145	205	1,566	61,535.0	645	1.885
7	4,092	2,400	1,600	8,092	17,931.0	1,125	3.637	25	2,158	235	150	2,543	63,222.0	1,125	1.918
8	3,267	1,800	1,200	6,267	21,6°0.5	1,125	2.904	26	2,328	380	230	2,938	65,465.0	1,125	2.069
9	3,440	1,000	1,500	5,940	24,964.0	1,125	3.057	27	2,612	575	210	3,397	67,935.0	1,125	2.321
10	2,790	820	450	4,060	28,079.0	1,125	2.480	28	2,332	480	245	3,057	70,407.0	1,125	2.072
11	2,418	740	500	3,658	30,683.0	1,125	2.149	29	2,605	545	310	3,460	72,785.5	1,125	2.315
12	2,112	420	300	2,832	32,948.0	1,125	1.877	30	2,312	510	210	3,032	75,334.0	1,125	2.055
13	2,325	340	150	2,815	35,166.5	805	2.888	31	2,046	325	290	2,661	77,513.0	1,125	1.818
14	2,325	320	190	2,835	37,491.5	805	2.888	32	2,280	385	250	2,915	79,676.0	1,125	2.026
15	2,976	450	325	3,751	40,142.0	805	3.696	33	2,523	387	268	3,178	82,077.5	1,125	2.242
16	2,232	360	380	2,972	42,746.0	805	2.772	34	1,308	175	95	1,578	83,993.0	1,125	1.162
17	2,670	380	340	3,390	45,197.0	805	3.316								
18	3,680	810	580	5,070	48,372.0	1,125	3.271	Total	84,647	23,932	17,548	126,127		36,170	

legal, and berried categories, equation (1) can be rewritten as

$$U_l + U_s + U_b = q_l(K_l - CC_l) + q_s(K_s - CC_s) + q_b(K_b - CC_b); \quad (2)$$

where the subscripts l, s, and b correspond to the legal, sublegal, and berried categories. During the intensive fishing at Laysan bank, sublegal and berried slipper lobster were returned after capture. To eliminate inaccuracies associated with the possibility of returned lobster being recaptured, only the legal terms in equation (1) were used:

$$U_l = q_l(K_l - CC_l) = \hat{U_l} - q_l(CC_l), \quad (3)$$

where $\hat{U_l}$ is the CPUE of legal slipper lobster at the preexploited stock size. By using ordinary least squares on equation (3), $\hat{U_l}$ and q_l can be estimated. Given that $\hat{U_l} = q_l K_l$, then K_l is estimated by dividing $\hat{U_l}$ by q_l.

Results

Effort was concentrated in the northwest corner of Laysan bank but extended south to a sharp drop-off along the southern portion of the bank (Fig. 2). Normally the vessel set seven strings in the northwest corner at 30-200 m, but for a brief time (5 days), two strings (320 traps) were moved from the area to explore other potential fishing sites. Catches in these traps were poor and predominantly composed of spiny lobster, which were returned to the water; therefore, these traps and catches were eliminated from the totals. Catches along the northwest corner of the bank were almost all slipper lobster. About 126,000 total slipper lobster (all categories combined) were landed from 36,000 trap-hauls, yielding an overall CPUE of 2.34 legal (retained) and 3.487 total slipper lobster per trap-haul (Table 1).

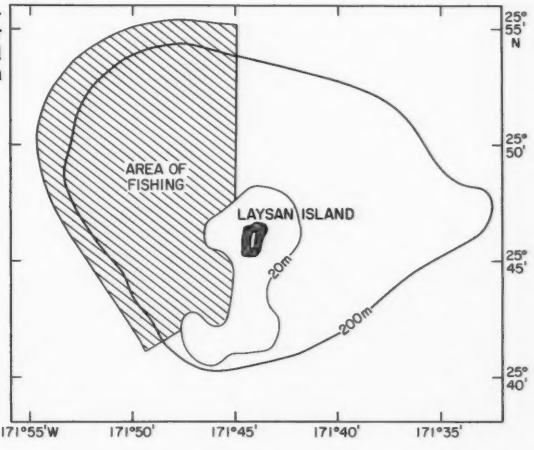


Figure 2.—Area of intensive slipper lobster fishing by a commercial lobster vessel on Laysan bank, Hawaii.

The CPUE data for legal slipper lobster were fit to the Leslie model (Ricker, 1975). The CPUE was calculated on a catch per trap-haul basis and regressed against the adjusted cumulative catch (Fig. 3), which was the cumulative catch at the start of a fishing day plus half of the catch taken during that day (von Geldern, 1961). The slope of the predicted line

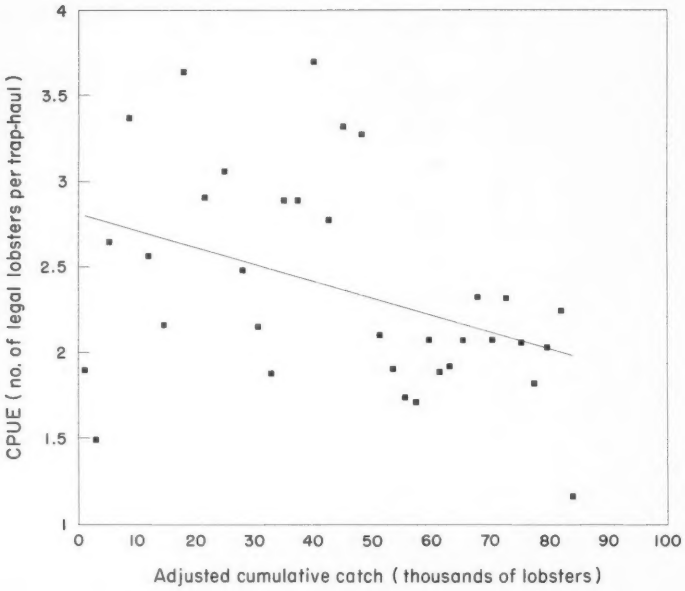


Figure 3.—Leslie model applied to the intensive fishing experiment for slipper lobster at Laysan bank, Hawaii. Each point represents 1 day of fishing. Data are from Table 1.

depicted in Figure 3 was significantly less than zero (one-tailed t-test, $P = 0.01$; $t = -2.45$; df = 32); however, the Durbin-Watson statistic (1.12) indicated autocorrelation problems, which could bias parameter estimates. By applying the Cochrane-Orcutt procedure (Wittink, 1988), the problem was corrected (DW = 2.04); the slope of the corrected line was significantly less than zero (one-tailed t-test, $P = 0.05$; $t = -2.25$; df = 32). The slope of the corrected line is -1.52×10^{-5} (SD = 6.76×10^{-6}), and the y-intercept is 3.10 (SD = 0.204). Therefore, the catchability coefficient is an estimated 1.52×10^{-5} trap-haul^{-1}, and the initial stock size is 204,000 slipper lobster with tails of 85 g or greater [confidence intervals: $P(7.49 \times 10^{-6} < q < 1.22 \times 10^{-5}) = 0.95$ and $P(181{,}945 < K < 970{,}786 = 0.95$, respectively]. An estimate of CPUE at virgin biomass is 3.10 [confidence interval: $P(2.68 < u_K < 2.94) = 0.95$].

As suggested by several previous investigators, the possibility of heteroscedasticity in the plot of CPUE against adjusted cumulative catch was explored by using the Goldfeld-Quandt test in Wittink (1988). A regression of CPUE on adjusted cumulative catch revealed that the sample variance (S) for the first 14 fishing days ($S^2_1 = 0.417$) and the last 14 fishing days ($S^2_2 = 0.105$) indicated no evidence of heteroscedasticity ($S^2_2/S^2_1 < F_{12,12}$ at 0.05). In addition, a runs test on the signs of the residuals indicated they were randomly sequenced ($P > 0.50$). The effects of the lunar cycle were tested by using a dummy variable and found not to be statistically significant ($P = 0.05$).

Discussion and Extrapolation of Results

The commercial data presented appear to give reasonable results; however, initially it may be appropriate to consider whether any of the basic assumptions of the Leslie model were violated. The initial assumption of an isolated population is evident by the geographical features of Laysan bank, which rises out of several thousand meters of water. Although the recruitment pattern of spiny lobster larvae in the NWHI is believed to be region-wide (MacDonald, 1986), there is no evidence to support postsettlement migration between banks by any species of lobster. Bathymetric charts of the fishing area show a sharp drop-off on the southwestern corner of the bank that may act as an additional physical barrier to substantial immigration to or emigration from other parts of the bank during the fishing period. Anecdotal information from experienced lobster fishermen indicates that steep drop-off areas are not normally conducive to large concentrations of lobster, but slipper lobster may be present. The northern extent of trapping does not show as good a physical boundary as in the south, but no trap strings were fished east of lat. 171°45′W, except those eliminated as exploratory. Therefore, we believe our initial assumption was fulfilled during the experiment.

The second assumption that changes in population stock size were due only to fishing mortality is more difficult to prove, though there is little evidence to the contrary. The fishing period was relatively short; however, one cannot rule out the possibility that recruitment to the fishery may have occurred or that mortality was abnormal. Little information presently exists on the molting and recruitment patterns of slipper lobster. The time from their settlement as pueruli to recruitment to the fishery is estimated at 3.3 years (Polovina and Moffitt[5]), of which the 34-day fishing period represents a small (2.8 percent) proportion. No data exist on the proportion of the population undergoing molting, which may alter their foraging behavior and thus the probability of capture by baited traps. In other lobster species, these changes can cause corresponding changes in the catchability coefficients (Morgan, 1974; Newman and Pollock, 1974). Our data

[5]Polovina, J. J., and R. B. Moffitt. 1989. Status of lobster stocks in the Northwestern Hawaiian Islands, 1988. Honolulu Lab., Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-89-3, 10 p.

and statistical analysis indicate that q, the catchability coefficient, was constant during the exploitation at Laysan bank. Without any evidence to the contrary, we believe that the third assumption (i.e., catchability was constant) has not been violated. It would have been useful for the vessel to have returned later to the bank and fished the area again to determine whether the slipper lobster CPUE stayed depressed, but this did not occur. In addition, no length-frequency information was taken, so conclusions as to shifts in size classes cannot be made.

The fact that the data had to be corrected for autocorrelation can be explained by the fishing patterns of the vessel. While the strings were moved each day, the success on any one day clearly had an effect on where the traps were set the following day, and as CPUE levels dropped, the vessel changed its pattern of fishing altogether. Daily plots of trap string locations reveal the vessel initially fished perpendicular to the depth contours of the bank, but as CPUE dropped, the vessel apparently began to set strings parallel to the depth contours at 60-120 m to better target optimal fishing areas.

Many studies using intensive fishing experiments do so with the intent of determining absolute estimates of stock size over a given unit of area (square kilometer of habitat or linear kilometer of appropriate depth contour; Polovina, 1986; Ralston, 1986; von Geldern, 1961). The same exercise was attempted for the NWHI slipper lobster population, revealing surprising results. Lobster density determined on the west and northwest portion of Laysan bank was taken as a minimum estimate of unexploited stock size for the entire bank. We believe it is inappropriate to extrapolate this density over the entire area of the bank, given the reportedly poor catches for the exploratory strings set on the other side of the bank. The NMFS lobster assessment research data from 1985 and 1986 (NMFS unpubl. data) confirm that catch rates for slipper lobster by black plastic traps were greatest in the northwest corner of the bank and diminished substantially toward the southeast portion. Therefore, for this exercise, we have applied the absolute abundance in the area fished to the entire bank.

Table 2.—Estimated total catch per unit effort (CPUE; number of lobster per trap-haul) and stock size of slipper lobster in the lobster fishery in the Northwestern Hawaiian Islands, 1985-86[1]. NF = no fishing.

Location	CPUE 1985	CPUE 1986	Area[2] (km^2)	Stock (No.) 1985	Stock (No.) 1986
Nihoa	NF	1.04	124.8		17,708
Necker Island	0.83	0.40	1,913.2	216,654	104,412
French Frigate Shoals	0.41	0.39	538.8	30,140	28,670
Brooks Banks	1.84	1.50	406.2	101,973	83,130
St. Rogatien	0.91	0.66	476.4	59,148	42,899
Gardner Pinnacles	1.46	0.56	3,000.4	597,670	229,243
Raita	0.52	0.73	697.9	49,514	69,510
Maro Reef	1.63	1.04	1,887.6	419,785	267,838
Pearl and Hermes Reef	0.75	NF	426.7	43,663	
Kure Atoll	0.48	NF	66.0	4,323	
Lisianski Island	0.66	1.77	922.2	83,042	222,704
Midway	0.35	NF	268.4	12,817	
Other[3]		2.47	1,947.0		656,133
Total				1,618,729	1,722,247

[1]Clarke, R. P., S. G. Pooley, P. A. Milone, and H. E. Witham. 1988. Annual report of the 1987 western Pacific lobster fishery. Honolulu Lab., Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-88-5, 48 p.
[2]From text footnote 2.
[3]Includes Northampton Seamount, Pioneer Bank, Pearl and Hermes Reef, Midway, Kure Atoll, an unnamed bank north of St. Rogatien, and Laysan bank.

Assuming the density estimate from Laysan bank (K/482.2 km^2) is an appropriate indicator of the potential number per square kilometer (422 slipper lobster/km^2 at the 20-200 m depths), the entire NWHI (8,876 km^2 of potential habitat at the 20-200 m depths) would have 3.75 million legal slipper lobster. Previous estimates of K for the entire NWHI equaled 3-4 million legal spiny and slipper lobsters combined (Polovina, 1989). Fishery catch totals for spiny lobster were equal to or greater than those of slipper lobster during 1985-88. This method of assuming an even distribution of slipper lobster over the entire potential area yields results that are twice the previous estimates. Slipper lobster at Laysan bank apparently were concentrated on the northwest corner of Laysan bank for some unknown reason, and an alternative method of extrapolation was necessary to account for this patchiness.

The alternative method assumes that slipper lobster distribution varies from bank to bank in the NWHI. The only measure of relative abundance for all the banks fished is from commercial catch and effort data collected during the initial years (1985-86) of slipper lobster exploitation; however, as will be discussed later, these data have limitations also. The estimate of catchability coefficient for Laysan bank was applied to obtain bank-specific densities for those areas reported as being fished. These values were multiplied by the bank's horizontal planar area relative to Laysan bank (Table 2). The CPUE data represent total slipper lobster caught; therefore, the estimates were adjusted by the same factor as that seen at Laysan bank to exclude sublegal and berried lobster.

The resulting estimates of stock size appear questionable even when adjusted for catches of sublegal and berried slipper lobster. In the NWHI, a total of 1.19 million slipper lobster were reported caught in 1985 and 1.24 million in 1986. Adjusting these catches by eliminating the sublegal and berried lobster shows that 74 percent (797,194 legal slipper lobster) of the estimated stock were landed in 1985 and 72 percent (829,143 legal slipper lobsters) in 1986. The value of K is underestimated by this method, because CPUE values are reported without targeting information and represent a composite of the fishing effort for spiny and slipper lobsters. Information on the targeting practices of the fishermen is not available; therefore, effort segregation is impossible.

The data show that after day 13 of in-

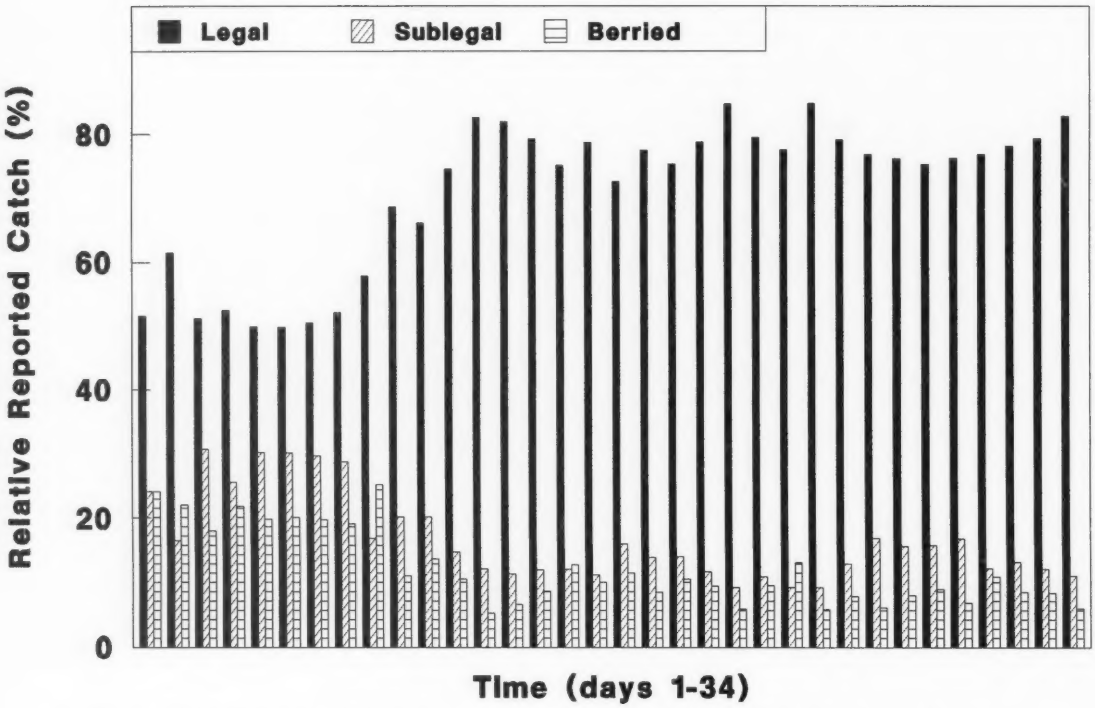


Figure 4.—Relative breakdown of reported catch categories (legal lobster have tails ≥ 85 g, sublegals have tails < 85 g, and berried are egg-bearing females) at Laysan bank, Hawaii, 1986.

tensive fishing at Laysan bank, the relative proportion of legal, sublegal, and berried slipper lobster stabilized (Fig. 4). Prior to that period, the percentages of berried and sublegal lobster were greater, indicating that berried females may have been releasing their eggs and becoming part of the retainable (legal) pool of lobster. However, the same trend is seen for sublegal lobster. This potential problem was cleared up in discussions with the skipper of the vessel, who indicated that numbers of berried and sublegal lobster were to be taken as estimates only and reflected estimating errors during the initial period of fishing, which was heavy even by commercial standards. As the slipper lobster CPUE declined, fishing returned to levels normally experienced by the vessel and allowed time to better estimate the numbers of sublegal and berried lobster returned to the water.

Conclusion

The use of the commercial data appears not to substantially violate any of the underlying assumptions of the Leslie model. The commercial catch data from Laysan bank produce reasonable estimates of K and q, but fishery-wide extrapolations yield estimates that are different than those presently accepted. Our results indicate that present estimates of K are probably low, and the true value probably lies somewhere between the two estimates presented here. Using two accepted methods of extrapolation, the low estimate for slipper lobster unexploited abundance is 1.2×10^6 legal slipper lobster, and the high is 3.8×10^6, yielding a mean of 2.5×10^6.

The catch data indicate that slipper lobster are extremely vulnerable to trapping, especially when concentrated in the proportions seen at Laysan bank. Catch and effort logs show fishermen have the ability to effectively target slipper lobster. Research directed at the causes of these concentrations is necessary, and if they are found to be related to some biological or behavioral phenomena and if present regulations are unable to sustain sufficient spawning stock biomass, a seasonal closure may be warranted for the slipper lobster fishery in the NWHI.

Acknowledgments

The authors would like to thank Darryl Tagami for his help and assistance and

Samuel Pooley, Jeffrey Polovina, C. D. MacDonald, and Stephen Ralston who reviewed this document. Finally, thanks go to K. Knutsen and D. T. Gunn for their substantial contributions to this study. Any errors are solely the responsibility of the authors.

Literature Cited

Crittenden, R. N. 1983. An evaluation of the Leslie-DeLury method and a weighted method for estimating the size of a closed population. Fish. Res. (Amst.) 2:149-158.

DeLury, M. D. 1947. On the estimate of biological populations. Biometrics 3:145-167.

Leslie, P. H., and D. H. S. Davis. 1939. An attempt to determine the absolute number of rats on a given area. J. Anim. Ecol. 8:94-113.

MacDonald, C. D. 1986. Recruitment of the puerulus of the spiny lobster, *Panulirus marginatus* in Hawaii. Can. J. Fish. Aquat. Sci. 43: 2118-2125.

Morgan, G. R. 1974. Aspects of the population dynamics of the Western rock lobster *Panulirus cygnus* George. II. Seasonal changes in the catchability coefficient. Aust. J. Mar. Freshwater Res. 25:249-259.

Newman, G. G., and D. E. Pollock. 1974. Biological cycles, maturity and availability of rock lobster *Jasus lalandii* on two South African fishing grounds. Union S. Afr. Sea Fish. Branch, Invest. Rep. 107:1-16.

Polovina, J. J. 1986. A variable catchability version of the Leslie model with application to an intensive fishing experiment on a multispecies stock. Fish. Bull. 84:423-428.

Polovina, J. J. 1989. Density dependence in spiny lobster, *Panulirus marginatus*, in the Northwestern Hawaiian Islands. Can. J. Fish. Aquat. Sci. 46:660-665.

Ralston, S. 1986. An intensive experiment for the caridean shrimp, *Heterocarpus laevigatus*, at Alamagan Island in the Mariana Archipelago. Fish. Bull. 84:927-934.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can., Bull. 191, 382 p.

Schnute, J. 1983. A new approach to estimating populations by the removal method. Can. J. Fish. Aquat. Sci. 40:2153-2169.

von Geldern, C. E., Jr. 1961. Application of the DeLury method in determining the angler harvest of stocked catchable-sized trout. Trans. Am. Fish. Soc. 90:259-263.

Williams, A. B. 1986. Lobsters—identification, world distribution, and U.S. trade. Mar. Fish. Rev. 48(2):1-36.

Wittink, D. R. 1988. The application of regression analysis. Allyn and Bacon, Boston, 324 p.

Distribution and Apparent Abundance of the Basking Shark, *Cetorhinus maximus*, off the Central and Southern California Coast, 1962-85

JAMES L. SQUIRE, Jr.

Background

Basking sharks, *Cetorhinus maximus*, are frequently observed along the central and northwestern southern California coast during the winter and spring months. These large plankton feeding elasmobranchs, second in size only to the whale shark, *Rhineodon typus*, had been the subject of a small commercial fishery off California in the late 1940's and early 1950's for their liver oil, rich in vitamin A, and in later years for reduction into fish meal and oil (Roedel and Ripley, 1950). These fisheries were sporadic and did not take basking sharks in large numbers.

Along the west coast of North America, the other substantial amount of "fishing" occurred in the 1950's when an eradication program was conducted in British Columbia waters by the Canadian Fisheries Department. Basking sharks were damaging Pacific salmon, *Oncorhynchus* spp., gill nets and a boat equipped with a sharp plow-like device was used to ram and kill basking sharks. About 50 sharks were reported killed during the first month of operation (Anonymous, 1956).

Basking sharks are fished by harpoon in many areas of the world (Norway, Ireland, Scotland, Iceland, China, Japan, Peru and Ecuador). These fisheries are reported to be sporadic due to periodic depletion of basking shark stocks (Compagno, 1984). Basking shark meat is used for human consumption, fresh or dried salted. The fins are used for shark-fin soup, the liver for squalene, the hide for leather, and the carcasses for fish meal (Compagno, 1984).

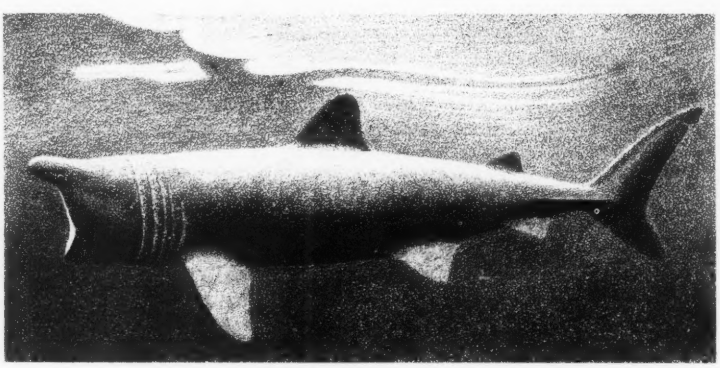
Observations on the occurrence of these sharks off central California, based on records of Edward Durden, an aerial fish spotter who worked with the basking shark fishery during the 1948-1950 period, were published by Squire (1967). These records indicate that basking sharks are commonly observed during October to May, with commercial concentrations noted off Pismo Beach and in Monterey Bay. This occurrence differs from that reported in north European waters where basking sharks are commonly observed during the summer.

In European waters it is proposed that they may shed their gill rakers in early winter, and hibernate near the bottom during the winter and spring months (Matthews, 1962). Along the California coast, they are frequently observed in areas of high phytoplankton abundance. In February 1955, the author recorded their occurrence in Monterey Bay during an aerial survey for pelagic fish (Anonymous, 1955). Seventy-four basking sharks were counted in the northeast portion of Monterey Bay, within 1.5 miles of shore. They appeared to be feeding in an area of patchy plankton.

This paper describes the distribution and abundance of basking sharks along the central and southern California coast (1962-85) as recorded by aerial fish spotters participating in the NMFS aerial monitoring program for coastal pelagic resources. Comparison is made of the seasonal occurrence of phytoplankton off the central California coast and the abundance of basking sharks.

Methods

In 1962, the National Marine Fisheries Service Southwest Fisheries Center (SWFC) started an aerial monitoring program for pelagic fish resources using the



The basking shark, *Cetorhinus maximus*.

James L. Squire, Jr., is with the Southwest Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92038.

services of aerial fish spotter pilots that work with the California commercial purse seine fleet. The spotter pilots search the offshore areas from off Baja California, Mexico, to the Monterey Bay area for concentrations of such target species as the northern anchovy, *Engraulis mordax*; Pacific or chub mackerel, *Scomber japonicus*; jack mackerel, *Trachurus symmetricus*; Pacific bonito, *Sarda chiliensis*; Pacific sardine, *Sardinops sagax*; and bluefin tuna, *Thunnus thynnus*. For the resource monitoring program the spotter pilots maintain a flight log indicating areas searched, species observed, and amount of fish observed (estimated in short tons) for the area, or numbers of schools and size (tonnage) of the schools. Aerial spotters under contract were also asked to make note of any basking sharks observed.

Aerial fish spotting records (1962-85) in the SWFC data base were searched for basking shark sightings. Data on numbers sighted are recorded by "block area," a 10′ longitude by 10′ latitude area (about 8 × 10 n.mi. at the latitude of California). This "block area" coding system is the same as that used by the California Department of Fish and Game for recording data from the marine waters off California. When a pilot enters a block area it is recorded as a block area flight (BAF). During 1962-85, aerial spotters recorded a total of 6,695 BAF's for the area north of Point Conception (Zones A and B) and 74,142 BAF's for the area south of Point Conception (Zones C and D). During 1962-85, 8,713 basking shark sightings were recorded, distributed along the coast from immediately south of Santa Cruz, California to off Port Hueneme, California, and along the Santa Barbara Channel Islands. Four basking sharks were recorded off northwest Baja California, Mexico.

Results

Figure 1 presents the geographical distribution of sightings, the total number of basking sharks sighted and average number sighted per sighting by block area during 1962-85. The area north of Point Conception, Monterey Bay (block areas 508, 516, 517) and the area off Point Buchon and Morro Bay (block areas 607, 615) had the greatest number of basking shark sightings. Block area 607 had the largest sighting record, 6,389 basking sharks, with an average of 96.8 sharks per sighting. South of Point Conception the greatest number sighted in any block area was the area southwest of Ventura (block 665) with an average of 6.7 individuals per sighting. In this area, block areas 664 and 683 had higher sighting rates, but few sightings (two for block 664 and one for block 683).

The monthly distribution of basking shark sightings for the coastal area from the Santa Barbara Channel to Monterey Bay as developed by the aerial monitoring program (1962-85) is compared with the monthly sightings in the Monterey Bay area as recorded by Edward Durden (Squire, 1967) in 1948-50 (Fig. 2). Both sets of observation data show the peak apparent abundance to be October with a lesser occurrence in February or March.

The Monterey Bay and central California coast is a major upwelling area and the highest phytoplankton concentrations are noted during the summer months. Figure 2 also shows the monthly distribution of phytoplankton volumes in the Monterey Bay area as recorded by Bolin and Abbott (1963). Zooplankton organisms, being grazers on phytoplankton, tend to coexist with phytoplankton, and the months of high phytoplankton should result in higher levels of zooplankton, the major food source for filter-feeding basking sharks. During the months of high phytoplankton volumes the occurrence of basking sharks is low. This may indicate that the basking sharks observed in greater numbers during the fall and winter are not necessarily in the coastal areas for feeding, but these concentrations in the inshore area could be related to mating as described by Compagno (1984) for the European population.

Abundance Trends

Greater abundance levels were observed prior to 1970. This is reflected in the number of basking sharks sighted per block area (for block areas having sightings) as shown in Figure 3. The distribution of sighting effort (number of BAF's) conducted north and south of Point Conception by year, is also given in Figure 3. The number of flights conducted north of Point Conception in the areas of higher basking shark abundance was much greater before 1970 than after. Aerial fish spotters were actively searching for Pacific (chub) and jack mackerel and Pacific sardine north of Point Conception in the 1960's, but after the decline of both the mackerel and sardine resources to very low levels, little aerial spotting effort was conducted north of Point Conception. Edward Durden (personal commun.) reported that from his experience it appeared that the abundance of basking sharks was much reduced in all areas in the 1970's.

A total of 399 sightings totaling 8,709 basking sharks were recorded for the coastal area from Port Hueneme to Santa Cruz, Calif. This was an average of 21.8 basking sharks per sighting. The average number was 51.9 basking sharks per sighting for the area north of Point Conception; for south of Point Conception the average number of basking sharks per sighting was 2.9. South of Point Conception the sighting level was 0.009 basking sharks per BAF (74,143 BAF). North of Point Conception the sighting level was 1.19 basking sharks per BAF (6,695 BAF).

It would appear that some increase in population levels of basking sharks south of Point Conception may have occurred since 1975 with a peak in 1981 (Fig. 3). Severe El Niño perturbations occurred in 1982 and 1983 (Quinn et al., 1987). These abnormally warm years, including 1984 which was warmer off southern California than during the El Niño period, may have reduced again the availability of basking sharks south of Point Conception.

Historical experience in other areas of the world indicates that basking sharks cannot sustain a prolonged intensive fishery (FAO, 1984). Basking sharks, like many other elasmobranchs, have a slow growth rate and low fecundity (Holden, 1973). Fisheries in other parts of the world tend to sporadically fish the elasmobranch resource, as their abundance evidently declines rapidly during fishing (Compagno, 1984). Abundance surveys of the California basking shark resource

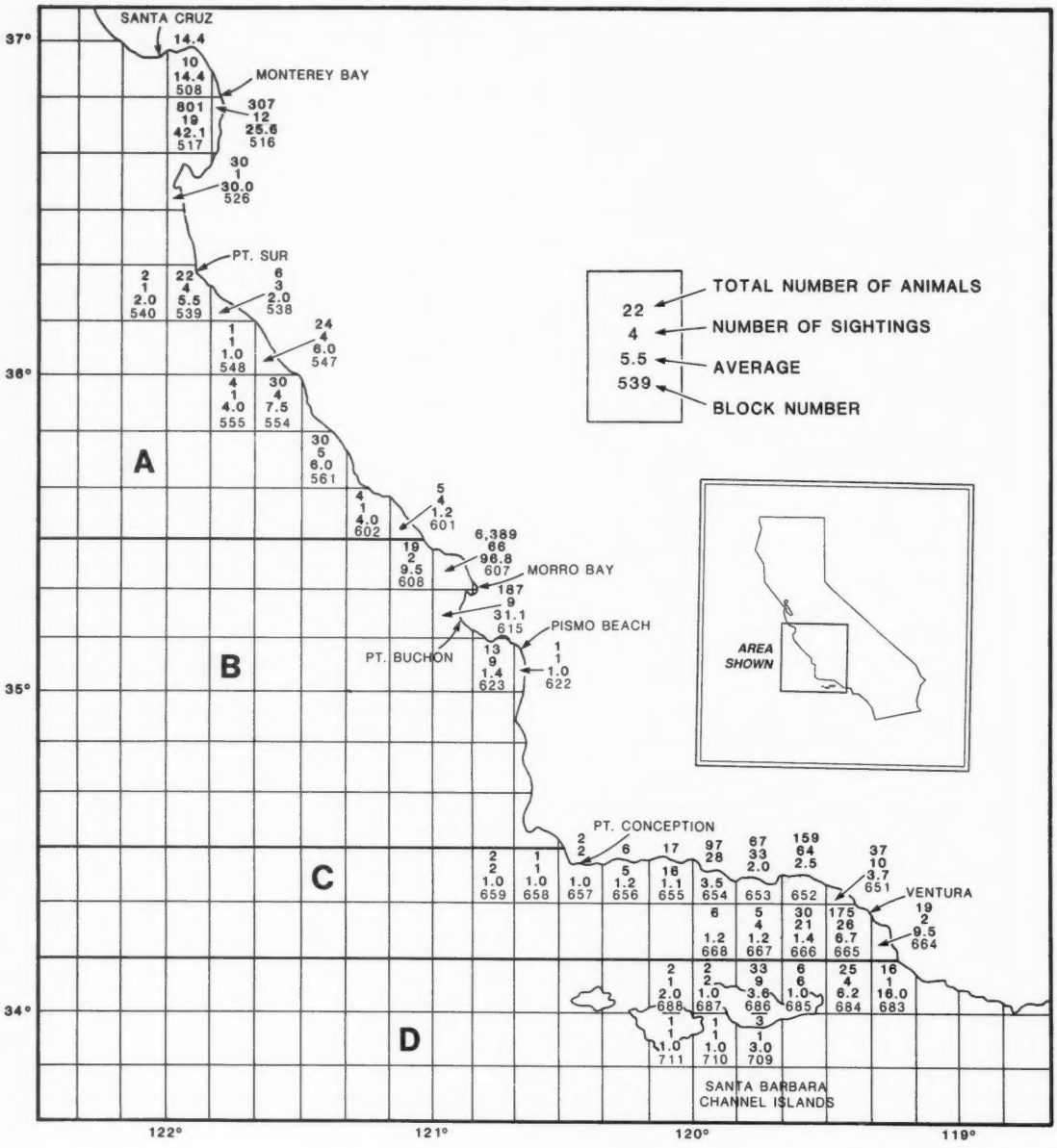


Figure 1.—Distribution of sightings, total number of basking sharks sighted, and average number sighted per sighting by block area (1962-85).

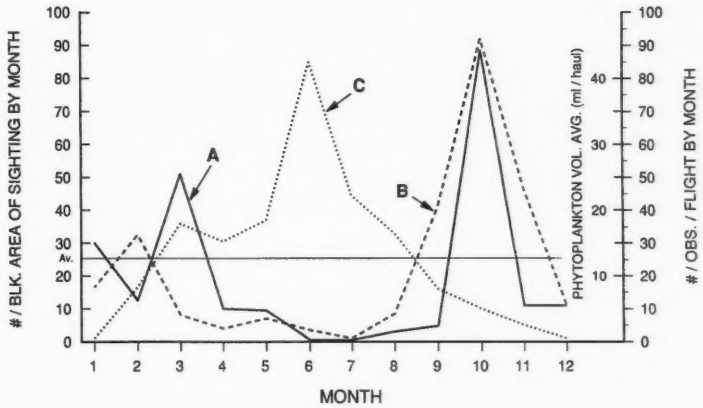


Figure 2.—A = average number of basking sharks sighted per block area, by month, by the aerial monitoring program (1961-85), B = number of basking sharks observed per flight in the Monterey Bay area, by month (1948-50), and C = average phytoplankton volumes recorded for Monterey Bay, by month (1954-60).

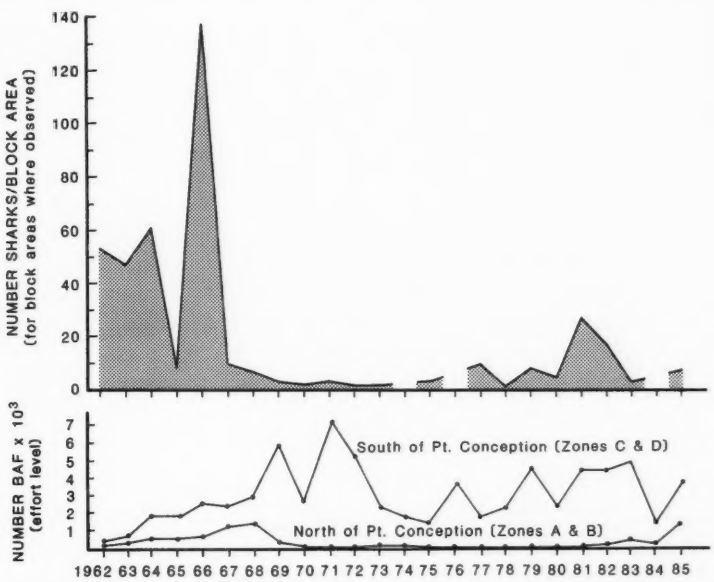

NUMBER SHARKS/BLOCK AREA
(for block areas where observed)
NUMBER BAF x 10³
(effort level)
South of Pt. Conception (Zones C & D)
North of Pt. Conception (Zones A & B)
1962 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85

Figure 3.—Number of sharks per block area, for block areas where observed, and number of block area flights (BAF's) north and south of Point Conception, Calif.

should be conducted to establish a "base level" of apparent abundance prior to any commercial fishing, and compared with the historical abundance levels presented here. Continuing the survey program to monitor changes in apparent abundance from fishing would then provide necessary information for resource management.

Literature Cited

Anonymous. 1955. Aircraft spotting flight 55-2. Calif. Dep. Fish Game, Memo. Rep., 4 p.

_____. 1956. Ship spears shark. Pop. Mech. 1956(11):172-173.

Bolin, R. L., D. P. Abbott. 1963. Studies on the marine climate and phytoplankton of the central coast area of California, 1954-1960. Calif. Coop. Oceanic Invest. Rep. 9:23-45.

Compagno, L. J. V. 1984. Sharks of the world. FAO Fish. Synop. 125, FAO Species Cat. 4, pt. 1, 249 p. Food Agric. Organ. U.N., Rome.

Holden, M. J. 1973. Are long-term sustainable fisheries for elasmobranchs possible? Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 164: 360-367.

Matthews, L. H. 1962. The shark that hibernates. New Sci. 13:756-759.

Quinn, W. H., V. T. Neal, and S. E. Antunez de Mayolo. 1987. El Niño occurrences over the past four and a half centuries. J. Geophys. Res. 92(C13):14,449-14,461.

Roedel. P. M., and W. Ripley. 1950. California sharks and rays. Calif. Dep. Fish Game, Fish. Bull. 75, 88 p.

Squire, J. L., Jr. 1967. Observations of basking sharks and great white sharks in Monterey Bay, 1948-50. Copeia 1967(1):247-250.

Blue Marlin, *Makaira nigricans*, Movements in the Western North Atlantic Ocean: Results of a Cooperative Game Fish Tagging Program, 1954-88

W. N. WITZELL and E. L. SCOTT

Introduction

The Cooperative Game Fish Tagging Program was created in 1954 as a joint effort between fisheries scientists and fishermen to provide information on the movements of various pelagic fish species occurring throughout the western central Atlantic Ocean (Scott et al., In press). Present tagging efforts target the following pelagic species: Blue marlin, *Makaira nigricans*; white marlin, *Tetrapturus albidus*; sailfish, *Istiophorus platypterus*; swordfish, *Xiphias gladius*; bluefin tuna, *Thunnus thynnus*; yellowfin tuna, *Thunnus albacares*; and bigeye tuna, *Thunnus obesus*). All of these pelagic species have high recreational values, but the blue marlin is undoubtedly the most prestigious to capture. In fact, an entire multi-million dollar industry has evolved around this single "rare event" species.

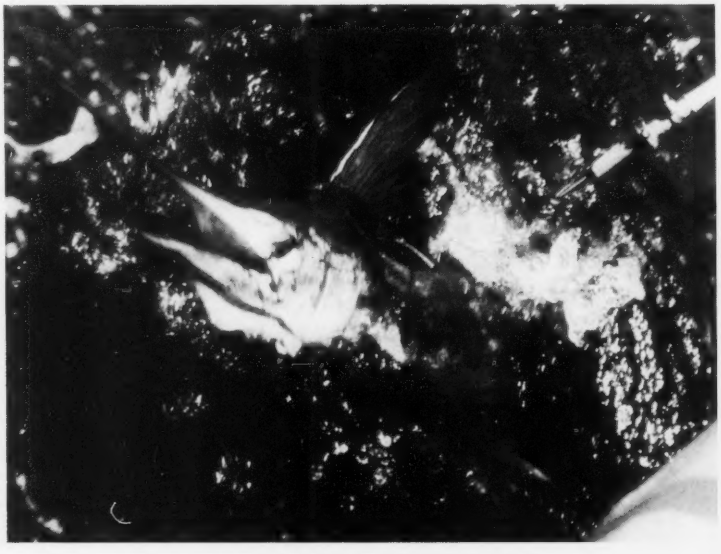
Determining the migration patterns of these species is necessary for formulating sound management strategies, as mandated by the Magnuson Fishery Conservation and Management Act of 1976, and the Atlantic Billfish Fishery Management Plan (USDOC, 1988). Migration patterns of many of these fish are emerging through rigorous tagging efforts and subsequent recaptures. However, the seasonal movements of blue marlin have not been well documented due to its exceptionally rare event status. This paper summarizes the available tag and recapture data for blue marlin in the western north Atlantic Ocean from 1954 to 1988.

The authors are with the Oceanic Pelagic Resources Division, Miami Laboratory, Southeast Fisheries Center, National Marine Fisheries Service, NOAA, 75 Virginia Beach Drive, Miami, FL 33149.

ABSTRACT—Blue marlin, Makaira nigricans, *tag and recapture data are summarized for 1954-1988. During this period, 8,447 fish have been tagged and only 30 (0.35 percent) have been returned. Results of the tagging program indicate that blue marlin not only travel considerable distances (7,000 km from the U.S. Virgin Islands to the Ivory Coast of West Africa), but have remained at large for up to 8 years. Seasonal movements, however, are difficult to determine accurately.*

Tagging Methods and Results

The basic mechanism and methodology of tagging large pelagics has been adequately described by Squire (1987) and Scott et al. (In press) for Pacific and Atlantic marlins, respectively, and is only briefly summarized here. Tagging equipment (tags, tag report cards, tag insertion poles, and instructions) are distributed upon request to interested fishermen. These anglers are instructed to insert the stainless steel dart tag anteriorly beside the dorsal fin when the fish is brought alongside the boat. After



A marlin is tagged beside the dorsal fin.

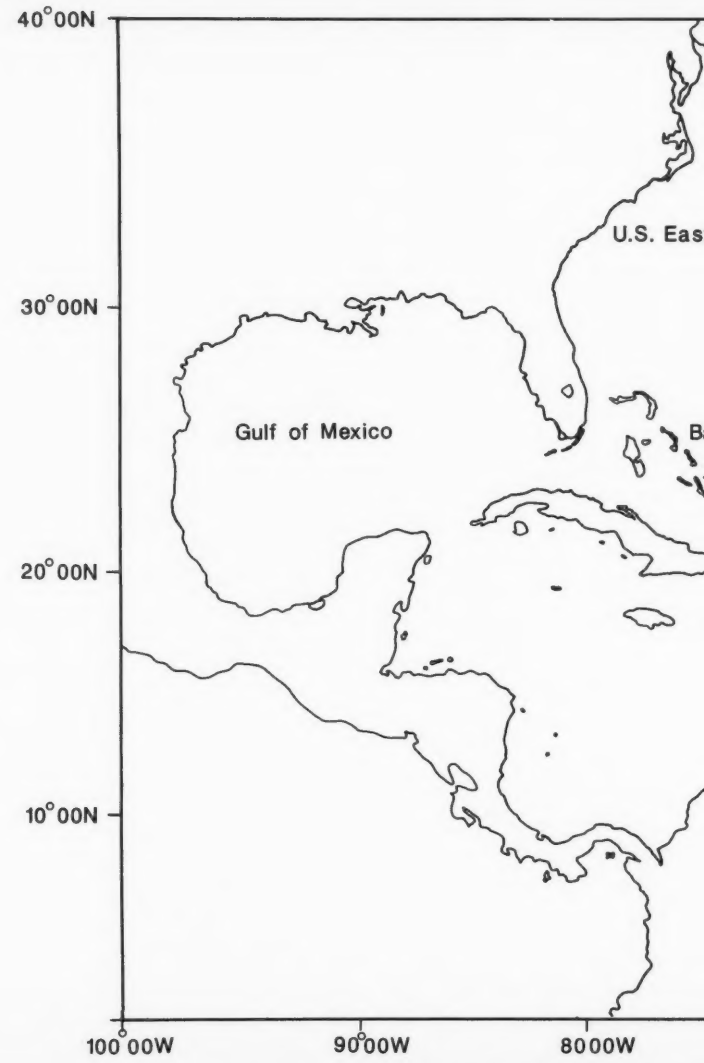
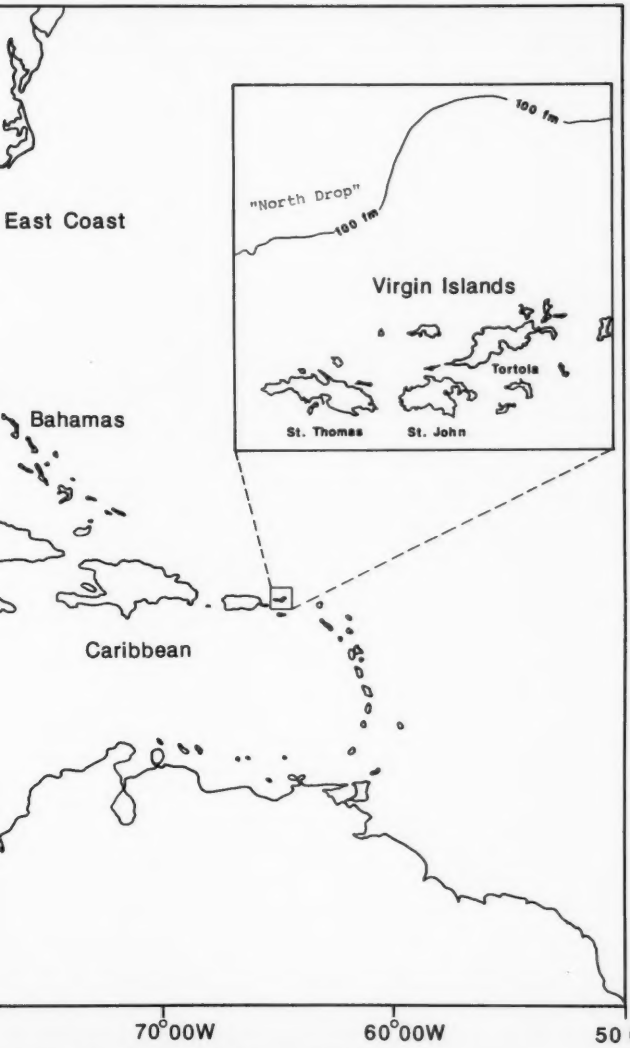


Figure 1.—Areas and locations of the NMFS Cooperati



operative Game Fish Tagging Program for blue marlin.

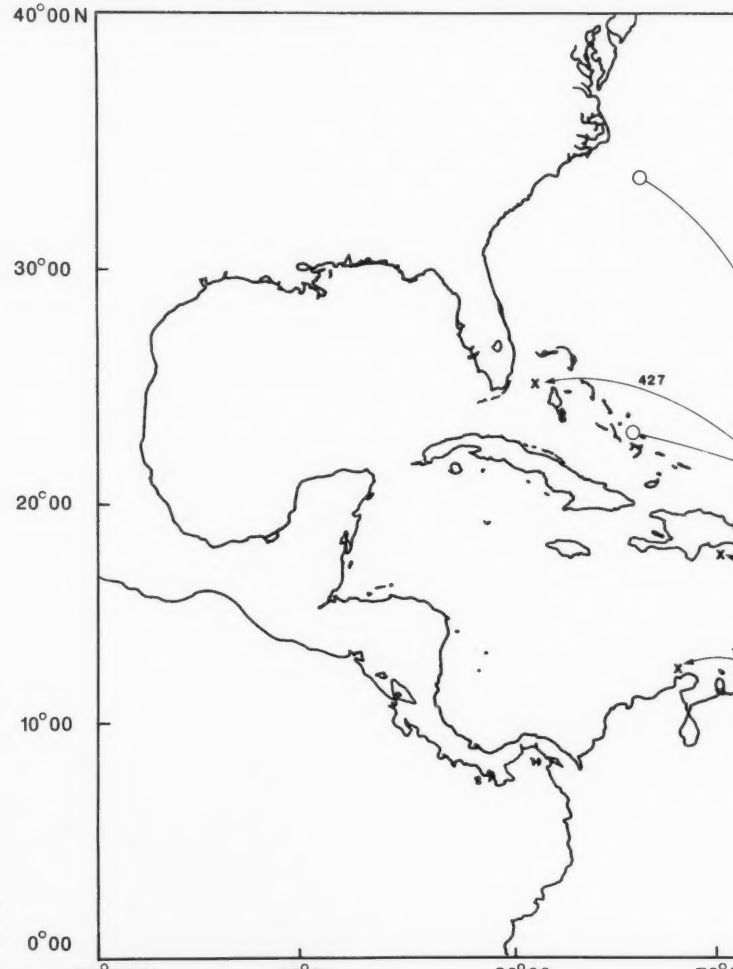
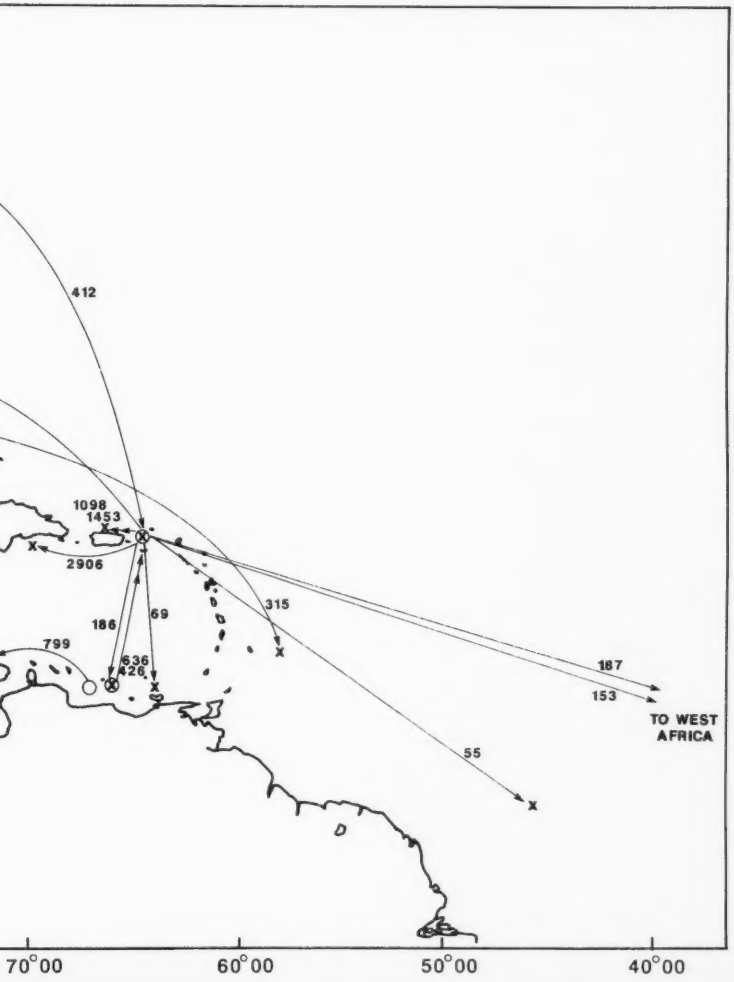


Figure 2.—Blue marlin tag/recaptures in the Caribbean from the NMFS Coopera
at large. Note: Arrows are not intended to indicate routes taken by the tagged fi
tagging location; X = recapture location.



operative Game Fish Tagging Program, 1954-88. Numbers indicate days fish were
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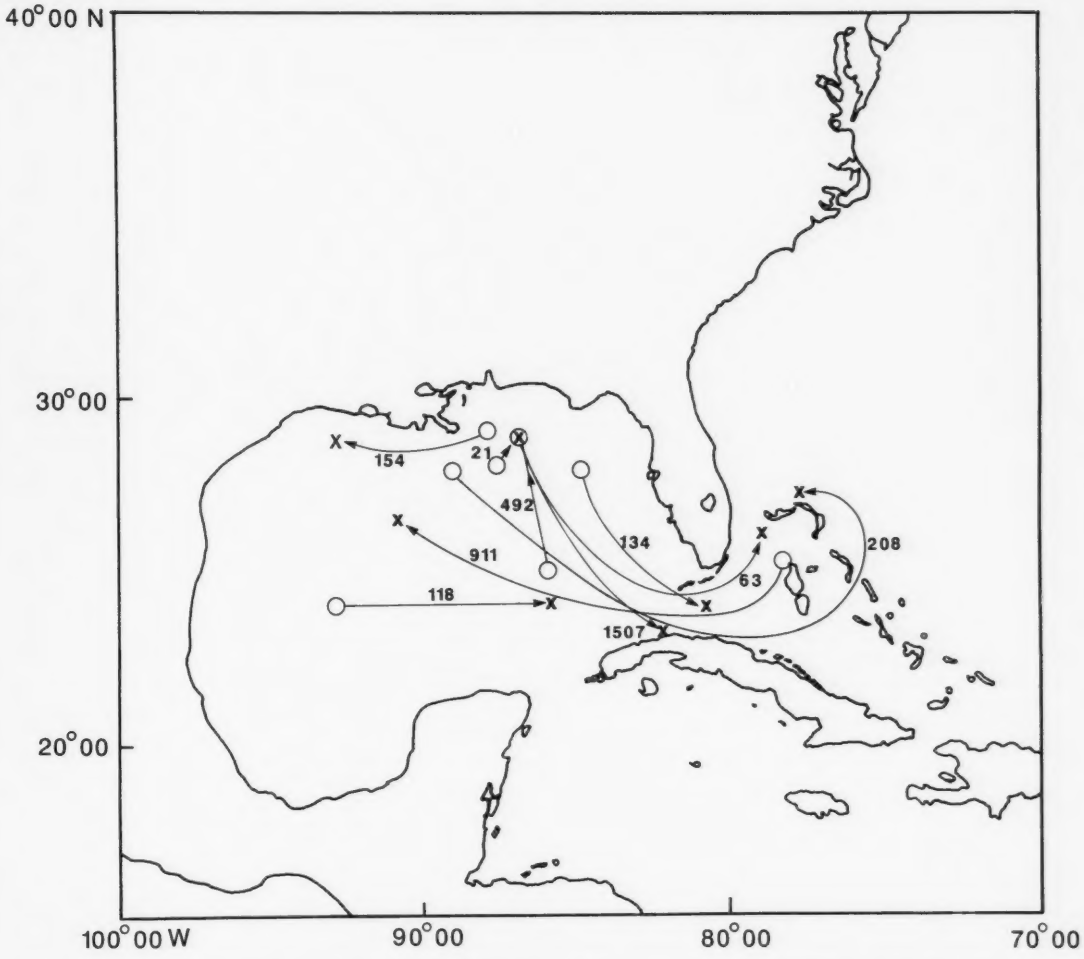


Figure 3.—Blue marlin tag/recaptures in the Gulf of Mexico and Bahamas areas from the NMFS Cooperative Game Fish Tagging Program, 1954-88. Numbers indicate days fish were at large. Note: Arrows are not intended to indicate routes taken by tagged fish, but only as a visual aid to differentiate tagging and recapture sites. O = tagging location; X = recapture location.

tagging a fish, the angler then fills out a tagging report card with the following requested information: Species, date, location, estimated length and weight, condition, bait, and the angler's and captain's names and addresses. The completed cards are then returned to the National Marine Fisheries Service (NMFS) for processing. Subsequently, the same basic information is requested of any angler returning a tag.

From 1954 through 1988, 8,447 blue marlin have been tagged. Return information has been received for only 30 (0.35 percent) of the number tagged. This extremely low return rate is undoubtedly due to a variety of factors, the most likely stemming from its rare event status, combined with its large geographic range, great mobility, tag loss, and nonreporting of fish caught with tags. Recreational rod-and-reel fishermen accounted for most of these fish tagged and returned, although participation from various commercial longline fleets is evident (Table 1). The locations of areas mentioned throughout the text are illustrated in Figure 1.

Discussion

Blue marlin in the Caribbean area, particularly the "North Drop" off St. Thomas in the Virgin Islands, appear to

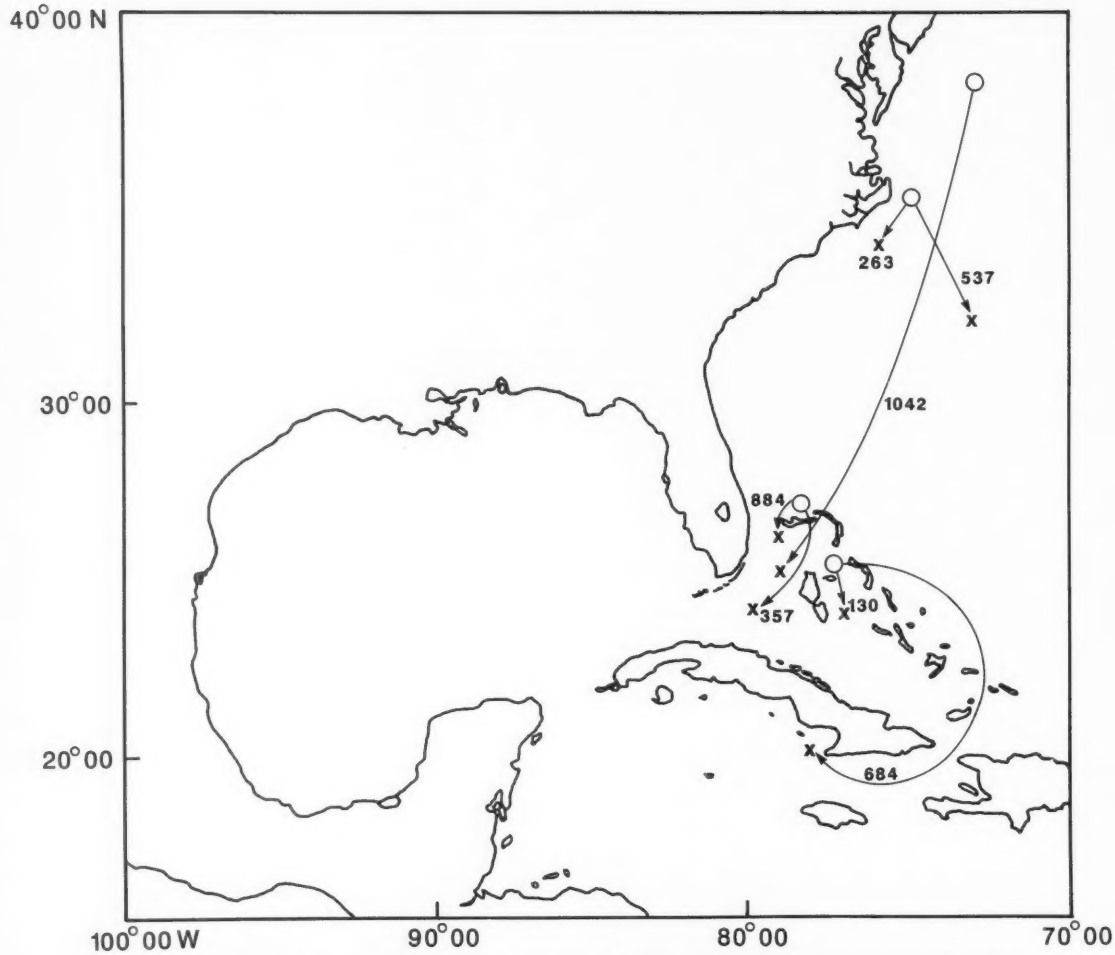


Figure 4.—Blue marlin tag/recapture in U.S. East Coast and the Bahamas are from the NMFS Cooperative Game Fish Tagging Program, 1954-88. Numbers indicate days fish were at large. Note: Arrows are not intended to indicate routes taken by tagged fish, but only as a visual aid to differentiate tagging and recapture sites. O = tagging, location; X = location.

be relatively abundant (Prince et al., 1989). This abundance is also reflected by the high numbers of fish tagged/released in this area (Table 2). Tag/recapture data (Table 3, Fig. 2) indicates that Caribbean-tagged blue marlin not only travel considerable distances, but they have remained at large for up to 8 years. Evidence indicates two-way movements between the Caribbean Islands and Venezuela and the Bahamas, and at least one-way travel from St.

Table 1.—Number of blue marlin recaptures reported to the Cooperative Game Fish Tagging Program by gear type from 1954 to 1988.

Item	Method	Number	Percent
Tagged	Rod and reel	26	86.7
	Longline	4	13.3
Total		30	100.0
Returned	Rod and reel	15	50.0
	Longline	10	33.4
	Handline	2	6.7
	Purse seine	1	3.3
	Found dead	1	3.3
	Unknown	1	3.3
Total		30	100.0

Table 2.—Number of blue marlin tagged and recaptured, reported to the Cooperative Game Fish Tagging Program, by area, from 1954-1988.

Area	Number tagged	Number returned	Percent of total returned
Caribbean	4,826	12	0.248
Gulf of Mexico	1,253	8	0.638
Bahamas	1,706	6	0.351
U.S. East Coast	662	4	0.604
Total	8,447	30	0.355

Table 3.—Summary of Atlantic blue marlin tag/recapture data by geographic location and season (calendar) from the Cooperative Game Fish Tagging Program, 1954-88.

Area and season tagged	Days free	Area returned	Season returned
Caribbean Sea			
Summer	1,453	Caribbean	Summer
Summer	1,098	Caribbean	Summer
Summer	799	Caribbean	Fall
Summer	427	Bahamas	Fall
Summer	187	W. Africa	Winter
Fall	153	W. Africa	Winter
Fall	55	Mid-Atlantic	Fall
Fall	69	Caribbean	Fall
Fall	636	Caribbean	Summer
Fall	428	Caribbean	Fall
Fall	186	Caribbean	Spring
Winter	2,906	Caribbean	Winter
Gulf of Mexico			
Summer	118	Gulf of Mexico	Fall
Summer	492	Gulf of Mexico	Fall
Summer	21	Gulf of Mexico	Summer
Summer	154	Gulf of Mexico	Fall
Summer	1,507	Gulf of Mexico	Summer
Summer	208	Bahamas	Winter
Fall	134	Bahamas	Winter
Winter	63	Gulf of Mexico	Spring
Bahamas			
Summer	315	Caribbean	Spring
Summer	684	Bahamas	Spring
Summer	130	Bahamas	Winter
Summer	357	Bahamas	Summer
Winter	884	Bahamas	Summer
Winter	911	Gulf of Mexico	Summer
U.S. East Coast			
Summer	537	U.S. East Coast	Winter
Summer	1,042	Bahamas	Summer
Summer	412	Caribbean	Fall
Fall	263	U.S. East Coast	Summer

Thomas to West Africa. It is unknown if the trans-Atlantic fish ever return to the western Atlantic, and fisheries scientists will never know without an extensive eastern Atlantic tagging project to document any west to east trans-Atlantic movements. Several animals were recaptured in the same general area as tagged, and it may be likely that these were repeat travelers that were returning to the area after multiple years of freedom. Although these data indicate considerable movements occur, they are too few to determine seasonality of movements accurately.

Blue marlin tag/recapture data from the Gulf of Mexico (Table 3, Fig. 3) indicates that seasonal movements may occur between the Gulf (summer) and the Bahamas (winter). It appears that, although some Gulf fish are undoubtedly remigrants, some may spend considerable time in the Gulf.

There have been relatively few blue marlin tagged and recaptured off the U.S. east coast and Bahamas (Fig. 3, 4; Tables 2, 3). All the marlin tagged from the U.S. east coast moved south, as far as the Bahamas and St. Thomas, while most of the fish tagged in the Bahamas were recovered in the same general area, except for one fish that moved into the Gulf of Mexico and one that moved into the Caribbean.

These data are too few to determine accurately blue marlin migration patterns. Evidence presented here suggests that the concentrations of marlin in the Caribbean area occur year-round, particularly near St. Thomas, and may move seasonally either to West Africa, the Bahamas, or to the U.S. east coast. It is interesting to note that there are no direct movements recorded between the Caribbean and the Gulf of Mexico.

Literature Cited

Prince, E. D., D. W. Lee, P. J. Pristas, J. P. Contillo, E. L. Scott, and J. E. Tashiro. 1989. Angler participation in SEFC oceanic pelagics programs, 1987. NOAA Tech. Memo. NMFS-SEFC-209, 48 p.

Scott, E. L., E. D. Prince, and C. D. Goodyear. In Press. History of the Cooperative Game Fish Tagging Program in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, 1954-1987. Pap. pres. at Int. Symp. Educ. Workshop on Fish-Marking Techniques, Seattle, Wash., June 27 - July 1, 1988.

Squire, J. L. 1987. Striped marlin, *Tetrapturus audax*, migration patterns and rates in the northeast Pacific Ocean as determined by a cooperative tagging program: Its relation to resource management. Mar. Fish. Rev. 49:26-43.

USDOC. 1988. Atlantic billfishes. Final rule to implement the Fisheries Management Plan for Atlantic Billfishes. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv. Fed. Regist. 53(188); 37765-37771.

Sea Scallop, Goosefish Landings Set New Records

Landings of sea scallops and goosefish (monkfish or angler) in the U.S. Northeast (Maine through Virginia) during 1989 set all-time record highs, according to NMFS data. Scallop landings were 31.6 million pounds worth 125.7 million dollars in dockside value. Goosefish landings were 24.8 million pounds worth 11.8 million dollars. Other species whose landings increased in 1989 were Atlantic cod, silver hake (whiting), yellowtail flounder, swordfish, and northern shrimp. Although landings of white hake decreased in 1989, their value nonetheless increased. Atlantic cod was the most landed seafood species in 1989, replacing Atlantic herring which dropped from first to second.

Table 1 lists the landings and values of 15 fish and invertebrate species in the U.S. Northeast for 1988 and 1989. For comparison only, the all-time record landings (and year in which they occurred) are also listed for these species.

Table 1.—Landings in the U.S. northeast for 1989, 1988, and the record year in pounds and dollars (data is in millions).

	1988		1989		Record	
Species	Pounds	Dollars	Pounds	Dollars	Pounds	(Year)
Atlantic cod	75.4	42.6	76.3	44.1	294	(1880)
Atlantic herring	89.1	5.2	73.7	4.4	201	(1902)
Silver hake (whiting)	35.2	8.5	37.9	9.4	134	(1957)
Sea scallop	28.3	120.0	31.6	125.7	32	(1989)
Goosefish (monkfish, angler)	16.6	10.1	24.8	11.8	25	(1989)
Pollock (Boston bluefish)	33.1	11.0	22.5	10.7	54	(1986)
Winter flounder (lemon sole, blackback)	17.6	21.4	14.3	20.5	35	(1981)
Summer flounder (fluke)	24.3	31.6	12.6	20.9	32	(1979)
Yellowtail flounder	9.3	11.1	11.2	14.5	83	(1963)
White hake	10.5	3.2	8.8	3.4	40	(1898)
Northern shrimp	6.8	7.5	7.4	7.6	29	(1969)
Scup (porgy)	11.6	7.6	7.1	5.9	49	(1960)
Swordfish	5.6	16.6	6.3	17.6	7	(1929)
Haddock	6.5	7.0	3.8	4.4	294	(1929)
Redfish (ocean perch)	2.4	1.5	1.2	0.8	258	(1951)

Cash Prizes Set for Atlantic Salmon Tags

The North Atlantic Salmon Conservation Organization (NASCO) has created a lottery to increase fishermen's return rates of tags found on harvested Atlantic salmon. Those fishermen returning tags will not only receive the current $15 (U.S.) reward, but will also be automatically eligible for a drawing with 31 cash prizes totaling $13,600. Prizes include a grand prize ($2,500), three first prizes ($1,500 each), three second prizes ($1,000 each), three third prizes ($500 each), and 21 fourth prizes ($100 each).

NASCO is an international, treaty-based organization which promotes conservation, restoration, enhancement, and sound management of salmon stocks in the North Atlantic. It has nine members: Canada, Denmark (i.e., Faroe Islands and Greenland), the European Economic Community, Finland, Iceland, Norway, Sweden, the Soviet Union, and the United States. Participation in the lottery, or "Atlantic Salmon Tag Return Incentive Scheme," by the nine NASCO members is voluntary. All but the Soviet Union are taking part.

According to Allen E. Peterson, Jr., Science and Research Director of the National Marine Fisheries Service's Northeast Region and one of three U.S. commissioners to NASCO, "tag returns provide important, if not essential, information on the biology and harvests of the stocks of North Atlantic salmon." He said such information "is particularly valuable for the U.S. effort to restore fish to New England rivers."

The lottery applies only to readily identifiable, external ("Carlin"-type) tags that are returned to an official tag-return agency. In the United States, the official tag-return agency is the Atlantic Salmon Tag Return Clearinghouse, NOAA, National Marine Fisheries Service, Woods Hole, MA 02543. Each April, the Clearinghouse will inform NASCO headquarters in Edinburgh, Scotland, of all eligible U.S.-origin tags that were returned. Tags returned to the Clearinghouse after the closing date will be eligible the following year.

All tag returns from NASCO members participating in the lottery are eligible for the grand prize drawing for $2,500 which will be announced at the NASCO annual meeting each June. The tag returns will then be sorted into the three Commission areas of NASCO—West Greenland, North American, and North East Atlantic—according to the place of harvest of the tagged salmon. Ten awards will then be selected randomly for each Commission area. The first selected will win $1,500; the second, $1,000; the third, $500; and the next seven, $100 each.

All U.S. tags returned from the United States and Canada will be entered into the grand prize drawing along with the North American Commission drawing. All U.S. tags returned from West Greenland will be entered into the grand prize drawing along with the West Greenland Commission drawing. All U.S. tags returned from East Greenland will be entered into the grand prize drawing along with the North East Atlantic Commission drawing.

NASCO headquarters will send checks in the appropriate amount within 60 days of the announcement of the awards. The first drawing of award winners was to take place at this year's seventh annual meeting of NASCO in Helsinki, Finland, during 12-15 June 1990.

Rule Asked for Mandatory Dealer Reporting for Atlantic Swordfishes

A proposed rule that would require mandatory reporting by all dealers handling Atlantic swordfish was published in the *Federal Register* on 29 December 1989, announced Andrew J. Kemmerer, Director, Southeast Region, National Marine Fisheries Service (NMFS). The proposed rule would implement a regulatory amendment to the Fishery Management Plan for Atlantic Swordfish (FMP). This proposed rule would require each dealer in the Atlantic swordfish fishery to provide information on all swordfish received and on other fish landed in conjunction with swordfish trips. The required information to be reported would include dates of receipt of swordfish; names and official numbers of the vessels from which swordfish were received; dates and ports of landing of the vessels; total carcass weights (by market category for swordfish and by species for related by-catch species received); prices paid for each market category and species; and individual carcass weights for swordfish. Although not required, individual carcass weights of the related by-catch species would also be desired.

Dealers would have the option of providing the information on a form available from the National Marine Fisheries Service or on copies of appropriate weigh-out sheets and sales receipts. Dealer reports for each month would have to be submitted to the Southeast Regions Science and Research Director so as to be received not later than the fourteenth day of the following month.

The information obtained from dealer reports would supplement the catch per unit of effort data from vessel logbooks by providing statistics on the size composition and total weight and value of landings of swordfish and associated species. This information is essential for stock assessments and for monitoring the status of stocks and the effectiveness of the FMP.

In addition to requiring dealer reporting, this proposed rule would: 1) Clarify the scope of the regulations; 2) modify the requirements and procedures for obtaining a vessel permit; and 3) modify the procedures for submitting the daily fishing records. Comments were accepted through the end of January 1990.

Crustacean Shell Disease May Be Aggravated by Environmental Stress

About 2 years ago, when sewage sludge dumping shifted from the 12-Mile Dumpsite in the New York Bight apex to the 106-Mile Dumpsite beyond the continental shelf-slope margin, many offshore lobstermen and deep-sea red crabbers in the vicinity of the 106-Mile Dumpsite felt that there was a significant increase in the prevalence and severity of shell disease in their catches. Shell disease is characterized by darkening, pitting, even penetration of the exoskeleton of these crustaceans. While there is no evidence that the disease affects the wholesomeness of these animals as seafood, it may affect their marketability due to discoloration/disfiguration, and conceivably it may affect their population distribution, abundance, and productivity.

The NMFS Northeast Fisheries Center has issued two reports on this topic. The first report, "Shell Disease of Crustaceans in the New York Bight" (NOAA Technical Memorandum NMFS-F/NEC-74), emanated from a joint NOAA and U.S. Environmental Protection Agency-sponsored scientific working group composed of Federal, state, and university scientists. The report finds that: 1) Shell disease is a natural phenomenon; 2) its prevalence and severity, however, may be greater in polluted or stressful habitats, suggesting that various stresses, including pollution, can trigger and/or aggravate the disease; and 3) there aren't enough data yet to determine if or how much the disease has population-level effects.

The second report, "Shell Disease among Red Crabs Inhabiting Submarine Canyons of the New York Bight" (NOAA Technical Memorandum NMFS-F/NEC-77), finds shell disease prevalence to be 92, 92, and 86 percent, respectively, among crabs in Hudson, Block, and Atlantis Canyons. A comparison of specimens collected in 1988 with those collected in 1884 and subsequently stored in the Smithsonian Institution shows that shell disease also occurred more than a century ago. Copies of either report are available upon written request to: Information Services Section, Northeast Fisheries Center, Water St., Woods Hole, MA 02543. Technical inquires on shell disease should be directed to: Carl J. Sindermann at the Oxford (Md.) Laboratory, telephone (301) 226-5193.

Threatened Status Eyed for Selected Salmonids

The National Marine Fisheries Service has published a new emergency rule to list the winter run of chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento River, California, as a threatened species under the Endangered Species Act of 1973. Meanwhile, the NMFS is also conducting a status review of sockeye salmon, *O. nerka*, populations in Idaho's Salmon River basin to determine if any should be proposed for listing as threatened or endangered under the ESA.

The chinook salmon of the Sacramento River was first listed by NMFS on an emergency basis on 4 August 1989. Since that time, NMFS has published a proposed rule to formally add the run to the list of threatened species (March 20, 1990 - 55 FR 10260). NMFS published this new emergency listing to avoid a hiatus in protection of the species until the formal listing process is completed. In 1989, the return of winter-run chinook salmon was estimated at only 500 fish, which is 75 percent below a consistent run size of 2,000 to 3,000 fish in recent years. This emergency rule includes a designation of critical habitat in a portion of the Sacramento River from Red Bluff Diversion Dam, Tehama County (River Mile 243) to Keswick Dam, Shasta County (River Mile 302) including the adjacent riparian zones, the water in the river, and the river bottom for winter-run. This section includes the portion of the river in which suitable conditions can be maintained for spawning, incubating eggs, and rearing juvenile fish. Winter-run chinook salmon in the Sacramento River are listed as threatened under the ESA and critical

habitat is designated effective 2 April 1990 through 28 November 1990, or until the final listing is effective, whichever occurs first.

New Marine Mammal Investigation in NEFC

A new Marine Mammal Investigation has been established by the NMFS Northeast Fisheries Center and assigned to the Fisheries Ecology Division. The center has been conducting marine mammal studies, largely through contracts with academic and private research institutions, for many years. Increasingly frequent and more comprehensive requests by resource and environmental managers for marine mammal information, however, have prompted the elevation of these studies into a formal investigation.

The new investigation's research will focus on: 1) The indirect interactions between marine mammals and commercially and recreationally important fish stocks through competition for space and food, 2) the incidental take of marine mammals during fishing operations and the effects on whale populations of whale watching operations, and 3) the current status of Northwest Atlantic marine mammal populations.

Leaflet Available on Nutritional Constituents of N.E. Seafood Species

The NMFS Northeast Fisheries Center has issued an information leaflet on "The Seafood Way to a Healthy Heart." The one-page leaflet includes a listing of the cholesterol, fat, and Omega-3 content in cooked, 4-ounce portions of 27 Northeast seafood species/products. (Omega-3 is a category of polyunsaturated fatty acids which are found in fish oils and which may have a therapeutic effect in the prevention of heart disease.)

The leaflet is the first in a series of informational leaflets to be issued by the Center which will summarize the practical applications and implications of Center research findings to current popular concerns. For copies of the leaflet, write: Information Services section, Northeast Fisheries Center, Woods Hole, MA 02543. For further information on Center research on nutritional constituents of seafood species/products, contact Judith Krzynowek, FTS 837-9226 or (508) 281-9226.

Temperature Trends in N.E. Waters Documented

A report on "Surface and Bottom Temperature Distributions from the Northeast Fisheries Center Spring and Fall Bottom Trawl Survey Program, 1963-1987," has been issued as Northeast Fisheries Center Reference Document 90-03. The report shows that, in general, water temperatures in the 1960's were quite cold, in the early to mid-1970's were warmer, in the late 1970's to early 1980's were intermediate between the two previous extremes, and in the mid-1980's were warm again. These data have important applications in fisheries ecology and management.

Copies of the report are available upon written request to: Information Services Section, Northeast Fisheries Center, Water St., Woods Hole, MA 02543. Technical inquiries on water temperatures should be directed to David G. Mountain, FTS 840-1271 or (508) 548-5123.

Indo-Pacific Crab Is Reported From New Jersey

An egg-bearing female of a western Pacific crab, *Hemigrapsis sanguineus*, was found in the Cape May, N.J., area in September 1989 by a Franklin and Marshall College biology student. This crab species, a noncommerical "shore" crab, is one of the commonest crabs in Japan, and is known from Sakhalin, Korea, and China south to Hong Kong. Larvae from the captured crab were reared through the early life stages.

It's not known whether this capture represents a freak capture of the only individual of this exotic species, or the first capture from an established population. If the latter, it's not known what ecological effect this exotic species might have on the Northeast's tidal community. The Cape May area should be monitored for the occurrence of this species, suggests Austin B. Williams of the NMFS National Systematics Laboratory in Washington, D.C.

NMFS Decides Against Emergency Regulations for Atlantic Swordfish

The National Marine Fisheries Service (NMFS) decided not to implement emergency regulations for the Atlantic swordfish fishery according to William W. Fox, Jr., Assistant Administrator for Fisheries, in a 5 February 1990 announcement. The agency has been analyzing for several weeks the potential conservation benefits of implementing emergency regulations under the Magnuson Fishery Conservation and Management Act for the overfished Atlantic swordfish resource. The agency oncluded that emergency measures confined to the 200-mile zone, which could remain in effect for more than 6 months, would not have sufficient conservation benefits this year to justify their imposition through use of the Secretary of Commerce's emergency regulatory authority as provided by the Magnuson Act.

NMFS remains concerned about the overfished status of Atlantic swordfish and is committed to establishing effective conservation measures as soon as possible in cooperation with the Regional Fishery Management Councils. To be most effective, however, new U.S. swordfish regulatory efforts initiated through the Council fishery management plan process need to be coordinated with international negotiations aimed at achieving an effective international conservation program for Atlantic swordfish. NMFS is working through the International Commission for the Conservation of Atlantic Tunas to obtain, as soon as possible, the participation of all countries harvesting Atlantic swordfish in a successful international conservation effort.

Thailand's Shrimp Culture Growing

Pond cultivation of black tiger prawns, *Penaeus monodon*, has brought sweeping economic change over the last 2 years to the coastal areas of Songkhla and Nakhon Si Thammarat on the Malaysian Peninsula (Fig. 1). Large, vertically integrated aquaculture companies and small-scale rice farmers alike have invested heavily in the transformation of paddy fields into semi-intensive ponds for shrimp raising. They have also developed an impressive infrastructure of electrical and water supplies, feeder roads, shrimp hatcheries, shrimp nurseries, feed mills, cold storage, and processing plants. Located within an hour's drive of Songkhla's new deep-water port, the burgeoning shrimp industry will have direct access to international markets. Despite a price slump since May 1989, expansion on all fronts—production, processing and marketing—continues at a feverish pace. However, the industry faces significant problems, mostly related to the cost/price equation. Continued low prices over several years could eliminate all but the most efficient Thai shrimp producers.

This report focuses on the recent boom in black tiger prawn culture along the Songkhla-Nakhon Si Thammarat littoral region and details the experiences of three of the largest firms operating in the Songkhla area. Songkhla's National Institute of Coastal Aquaculture (NICA) has provided the technological foundation for the establishment of shrimp culture in this area. Since 1982, NICA has operated a large shrimp hatchery where wild brood stock are reared on high-quality feeds in optimum water temperature and salinity conditions. The initial buyers of NICA's shrimp postlarvae (pl) were small-scale shrimp farmers surrounding Songkhla Lake.

Table 1.—Thailand, Indonesia, and Philippine cultured shrimp harvests by quantity, 1984-88[1].

	Harvest (1,000 t)				
Country	1984	1985	1986	1987	1988
Thailand	13	16	18	25	55
Indonesia	32	37	41	45	52
Philippines	29	29	31	33	42

[1]Source: U.S. Embassy, Bangkok, Thailand.

Background

Thailand's shrimp culture industry is the fastest growing in Southeast Asia. In only 5 years, Thailand has outstripped its competitors to become the region's number one producer. Thai shrimp harvests in 1988 reached 55,000 metric tons (t), a 320 percent increase over the 13,000 t produced in 1984 (Table 1). Indonesian and Philippine harvests rose by only 62 percent and 51 percent, respectively, over the same time period. Thailand's 1989 farmed shrimp production is expected to nearly double, surpassing 100,000 t.

Thailand's rapid advance into commercial shrimp culture appears all the more remarkable given its late start. Thai farmers have long been adept at using traditional extensive shrimp farming methods. They diked off estuarine and coastal mangrove areas to trap brackish-water marine life, which they harvested after a 45- to 60-day growth period. This simple system gave an annual shrimp yield of about 40 kg per rai (6.25 rais equal 1 ha). Semi-intensive shrimp cultivation, a comparatively recent phenomenon, involves raising hatchery-produced pl on commercial feeds in growout ponds. This system yields from 500-1,000 kg/rai (3,100-6,300 kg/ha) per

Figure 1.—Thailand and its major shrimp culture area.

year. However, the system demands a measure of sophistication in fry and feed production and in pond maintenance. The intensive culture system employs extremely high stocking densities to boost production to 800-2,000 kg/rai (5,000-12,500 kg/ha), but there is the risk of shrimp losses from poor water quality, stress from overcrowding, and resultant diseases. One such disease, monodon baclovirus (MBV), virtually wiped out Taiwan's tiger prawn industry and opened lucrative international markets to new competitors, such as Thailand.

The explosive growth of the Thai cultured shrimp industry has been accompanied by the rapid expansion of shrimp hatcheries and feed mills. In 1985, Thailand had one shrimp feed mill and a market demand of 6,000 t. Three years later, there were 15 shrimp feed mills and a market demand of 100,000 t. Supplies of shrimp pl are obtained from government hatcheries, about 1,500 family-

owned backyard hatchery operations, and large-scale agro-industrial concerns.

The Songkhla Pioneer

In 1985, Aquastar[1], an American-owned consortium bought 64 ha of rice paddies adjacent to the sea in Songkhla's Ranod District. Aquastar's plan was novel: Expand shrimp cultivation beyond the confines of estuarine and mangrove regions to paddy land, which had a long history of indifferent success growing rice.

Aquastar stocked 24 demonstration ponds, each of 1 ha, in January 1988 with shrimp pl from its nurseries, using an intensive culture density scheme to impress local farmers with the profit potential. Initial trials yielded harvests of 6 t/ha, gradually increasing to 7-8 t/ha. However, in practice, Aquastar is committed to a semi-intensive mode of shrimp culture: 15 to 20 shrimp/m, resulting in a 3-4 t/ha harvest.

Having proved the potential for shrimp culture, Aquastar began negotiations with local landowners to convert marginally profitable rice paddies into shrimp ponds. Within 1 year, it had contracted with 293 landowners in 7 locations, for a total of 310 ha of ponds. In the process, Aquastar standardized irregularly-shaped plots into 1-ha ponds. Most importantly, owners retained title to their plots and were encouraged to personally manage the new shrimp farms—a cooperative concept designed to maximize profits for both farm owners and the parent company.

Following the surveying and reorganization of land ownership, Aquastar provided training for pond owners in shrimp cultivation while constructing the ponds. Groups of 40 farmers were given a 20-day training course at company headquarters—half in classroom instruction, half in practical field work. Aquastar currently provides only transportation to the training center, but plans to build a dormitory and dining hall.

A critical factor in shrimp culture is the salinity of the pond water. Originally, Aquastar mixed fresh well water with sea water. The resultant brackish water had optimum salinity (25-26‰) for stimulating rapid shrimp growth. However, when neighboring farmers complained that water levels in their wells were dropping, Aquastar shut down its own wells and used sea water, with a salinity of 33-35‰ (31-33‰ during monsoons). While salt water culture results in a slower growth rate (11 days on the average), it has the advantage over fresh water of not harboring bacteria and disease. Moreover, brackish water ponds must be harvested before the monsoon season, as too much rain water subjects the shrimp to stress and inhibits growth. This not true of salt water ponds, since a moderate admixture of rainwater will only stimulate growth.

Aquastar's ponds are uniformly constructed. Each farmer owns about 1.3 ha; 1.0 ha of pond area and 0.3 ha of dikes, drainage and intake canals, roads, and caretaker huts. A concrete outer wall—15 cm higher than the local roadbed—encloses each of the groups of ponds and provides flood protection. The 1988 floods had no effect on Aquastar's ponds, though many nearby farmers' ponds were ruined. Each pond group is provided with intake canals on its outer border and discharge canals on the inner rim. Aquastar owns and operates each pond's intake pumping station and backup generators. Electricity is essential for the pond's aeration floats (eight per pond), which maintain a healthy flow of oxygen to the water.

Ponds are stocked from Aquastar's shrimp hatchery, which obtains brood stock from the Andaman Sea. The 10-tank hatchery produces 30 million fry per month, running continuous batches over a 6-day period before transferring them into a nursery for 15-18 days. From the nursery the shrimp are moved to grow-out ponds, where they are fed five times a day with pelleted feed from Aquastar's own mill (a capacity of 1,000 t, with planned expansion as more ponds go into production). Individual pond owners, assisted by company extension agents, manage the shrimp for the 4 months remaining until harvest. The first of Aquastar's seven groups harvested its first shrimp in mid-September. The remaining five groups completed pond construction in late August and September.

Aquastar transports the harvested shrimp to cold storage. The company is currently renting cold storage facilities on the Songkhla-Hat Yai road, but has begun construction of its own cold storage and processing plant on a 12-ha site in Singha Nakhon, 25 km from Songkhla's new deep-water port. The processing plant will have a capacity of 50 t per day when construction is finished at the end of January 1990. Processed shrimp will be packed in containers for shipment from Songkhla's deep-water port. Currently, Aquastar's markets are in Japan, but the company intends to expand to the United States in 1990 and to Europe in 1991. Thus, from egg to processed product for international markets, Aquastar functions as a vertically-integrated enterprise.

With phase one virtually complete, Aquastar is now beginning phase two—the development of 500-600 ponds. It plans to expand the size of its pond groups. While the first groups ranged from 26-30 ponds per group, 50 ponds is now the average and is much more cost-effective. The company hopes to organize future groups of 200-300 ponds. Bechtel Corporation is currently bidding to undertake all future pond construction for Aquastar, freeing it to concentrate on production and marketing. Aquastar continues to hold a significant advantage over other shrimp-growing companies in that, as a cooperative venture with local farmers, it is spared onerous land purchase costs and protracted negotiations.

Taiwanese Competition

Following Aquastar's success, other large shrimp-rearing companies targeted the Ranod-Hua Sai area. However, prime shrimp-growing areas are limited. North of Hua Sai, shrimp farming is generally carried out by traditional methods in mangrove areas from the Pakpanang District of Nakhon Si Thammarat through Surat Thani Province. South of Ranod, in Satingpla District, soils are too sandy and large parcels too small. As middle and large-sized shrimp companies sought to invest in the prime Ranod-Hua Sai area, land prices began to skyrocket.

In January 1988, Ting Thai, a Taiwanese-Thai joint venture, became Aquastar's first major competitor in the area.

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Land prices proved so prohibitive, and negotiations so torturous, that Ting Thai purchased only a 32-ha site in Hua Sai, preferring to buy 4 other sites of 56, 32, 32, and 5 ha, respectively, on the eastern shore of Songkhla Lake because the land was comparatively cheap and available in large parcels. Construction of a large hatchery and nursery was completed in May 1989 and Ting Thai began producing pl the following month. Ting Thai's feed mill, 12 km north of Hat Yai, came on-line at about the same time. A cold storage and processing plant will be located nearby, with the first stage of construction to be completed in 16 months. Further expansion is scheduled over a 3-year period.

Despite progress in the development of a vertically-integrated infrastructure, Ting Thai's selection of the four lakeside ponds has caused it major problems. The lake sites are salt-marsh peat and clay, and are highly acidic. Such soils call for periodic liming and special pond construction techniques. The ponds must be created by building dike walls. However, ponds built in this way require pumping intake and drainage water in and out of the ponds at extra cost. (Aquastar's ponds rely on a simple gravity flow system for drainage.) More seriously, the brackish water from the lake used in the ponds is of inferior quality. The area is one of intense aquaculture use, especially around the island of Koh Yoh, where local farmers have set up hundreds of sea bass and shrimp cages. In addition, there is minimal tidal flow, allowing insufficient drainage and the danger of the spread of diseases.

Given the severe water quality problems, Ting Thai lowered its stocking density from 25-30 pl/m^3 to 20. It stocked three ponds with pl in July 1989; two other ponds are still under construction. The company plans to harvest in November in the hope of beating the onset of the northeast monsoons, which will slow shrimp growth. Until Ting Thai's own processing plant is in operation, it has contracted with the Seahorse Packing Company in Songkhla to wash, chlorinate, head, and grade its first harvests. Ting Thai's goal is to purchase a total of 640 ha of ponds, preferably in the area of Hua Sai, although this will be an expensive and time-consuming operation, and will depend on the results of the initial harvests.

P. Charoen Phan Group

The P. Charoen Phan Group (CP), a Bangkok-based agro-industrial conglomerate formed in 1923, is a major producer of shrimp, pigs, ducks, and chickens, as well as tropical fruits, corn, soybeans, and sorghum. CP is the world's fifth largest producer of animal feeds and employs 12,000 people in Thailand, Malaysia, Singapore, Indonesia, Hong Kong, Taiwan, Belgium, China, and the United States. The company's gross annual turnover is estimated at $2 billion. Recently, CP arranged for a $60 million 5-year revolving credit loan through a consortium of Japanese banks. Given CP's interests and financial resources, it was a logical step for CP to move into the profitable shrimp farming industry. In one year, CP purchased large tracts of paddy land in Hua Sai to convert to shrimp ponds.

CP is currently involved in two shrimp farming projects: One is a joint venture with Mitsubishi of Japan and the other is CP-owned. Construction on both projects began in January 1989. The hatchery at CP/Mitsubishi was scheduled to be completed by the end of September, with a capacity of 10 million pl per month. A nursery was to be ready to begin operations shortly thereafter and CP/Mitsubishi planned to stock 80 ha of grow-out ponds. The CP-owned project's grow-out ponds will total 96 ha in the first stage of development, with another 80 ha to come on-line in the second stage. Both projects will use 100 percent sea water. While this is the company's first venture into seawater-irrigated ponds, results of an earlier 80-ha project in a Pattaya estuary site convinced the company to revert to pure sea water. At a 34‰ salinity level, seawater shrimp matured only 2 weeks later than shrimp in brackish water and proved to have a superior taste. Both projects in the Hua Sai area will be supplied by the CP feed mill in Hat Yai. CP plans to use intensive cultivation methods, stocking 30 shrimp/m^3 and harvesting 6 t/ha from 2-ha ponds. Its first harvest from 10 ponds was expected in February 1990.

CP's cold storage and processing plant was scheduled for completion in early March 1990. CP estimates that it will produce 30,000-40,000 t annually once it becomes fully operational. The company will emphasize quality control and plans to ship fully processed shrimp—headless, boiled, peeled, breaded, etc.—in containers from Songkhla. CP/Mitsubishi intends to obtain Japanese registration of its processing plant to avoid port inspection delays of its product in Japan.

Both CP and CP/Mitsubishi plan to try intensive shrimp culture, but have decided not to expand their own pond area for the present. In the future, they will contract with local shrimp farmers, with CP providing pl for stocking, feed, and marketing services and the local farmers providing the ponds and labor. As pond farming is labor-intensive, the CP view (like that of Aquastar) is that individual farmers will manage their shrimp more conscientiously than will hired help. The exact form the relationship between CP and local farmers will take—contracts, cooperatives, etc.—is still open, however. In any case, the potential for growth is enormous as CP's newly installed pumping system can move 4 m^3 of sea water per second—plenty to share with cooperating private farmers in the future.

Overdevelopment Problems

The three large companies profiled above have been joined in the Ranod-Hua Sai area by at least 10 mid-sized companies with holdings of 16-32 ha, plus countless numbers of small-scale pond owners. The greatest problem that all face is the plummeting price of shrimp in the wake of a world-wide supply glut.

When Aquastar harvested its first crops in July 1988, shrimp prices stood at 250 baht/kg ($10.00/kg at the conversion rate of 25 baht = $1). By January 1989, the price had fallen to 150 baht ($6.00)/kg. Even at this price, Aquastar cooperative farmers were still making substantial profits (Table 2). As there are two harvests per year, farmers could take in a gross income of 430,000 baht ($17,200) per year. Subtracting construction costs and bank loan repayments leaves individual net income at about 300,000 baht ($12,000) per year. After 3½ years, the farmer should

Table 2.—Cost analysis per shrimp pond in Thailand[1].

Item	Cost (Baht)	Item	Cost (Baht)
Feed	180,000	Harvesting	5,000
Maintenance	55,000	Chemicals	3,000
Postlarvae	38,000		
Electricity	20,000	Total costs	310,000
Pumps	9,000		
Revenues per crop: 525,000			
Net profit per crop: 215,000			

[1]Source: U.S. Embassy, Bangkok, Thailand.

be able to clear startup debts and begin to accrue all profits. Even during the repayment stage, the net income for the shrimp farmer of 300,000 baht far exceeds the 20,000 baht per ha he would have received from his former rice crop.

Unfortunately these equations were upset in May 1989, as Japanese importers—who buy 70 percent of Thailand's shrimp exports—stopped taking new orders. Japan's domestic shrimp supplies soared to a 5-month inventory, as opposed to the normal 3 months. The Thai market price suddenly dropped to only 96 baht ($3.84)/kg. This crisis provoked protest demonstrations by shrimp farmers in Bangkok and, ultimately, a government investigation into the problems plaguing the overheated shrimp industry. These included the following items.

High Feed Costs

Feed accounts for 60 percent of production costs. A Parliament Minister from a southern Thai province accused the CP Company, which controls 70 percent of Thailand's shrimp feed market, of keeping feed prices artificially high in order to drive out small-scale farmers and buy up their ponds. CP responded that, unlike the Philippines, which imports cheap American soybeans, Thailand protects its nascent soybean industry, which is geared to human consumption, by restricting importation of soybeans (including the lower grade soybeans used in shrimp feed). CP and other feed companies are also forced to use low-quality Thai fish meal, below 65 percent protein content, because they are prohibited from utilizing high-protein imported fish meal. Finally, the shrimp culture industry's huge demands for fish meal caused the fishmeal price to soar. In July, Thailand's Commerce Ministry approved the importation of 10,000 t of high quality fish meal to stabilize the market.

Electricity Costs

Shrimp farmers must pay higher domestic rates for electricity, rather than industrial rates. Thailand's Fisheries Department has recommended a reduction in these rates.

Shortage of Cold Storage

The shrimp industry must be able to preserve its production in order to weather periodic price slumps. On 21 June 1989, Thailand's Board of Investment decided to open its promotional privileges to investors in order to spur the rapid expansion of cold storage facilities.

Environmental Problems

The heavy concentration of shrimp farms near the cities of Samut Prakan, Samut Sakorn, and Samut Songkhram (near Bangkok) has already led to severe water quality problems and the threat of another disease disaster similar to the one in Taiwan. So far, in Ranod and Hua Sai, water quality has remained good. Shrimp ponds are disease-free and are cleaned after each harvest. Longer-term environmental effects, however, have yet to be addressed. Among these are the changing depth and salinity of Songkhla Lake, the drawing off of the Ranod-Hua Sai aquifer by well pumps, and the discharge of shrimp wastes into the sea. Bechtel Corporation has offered to do an environmental impact study prior to its proposed pond construction program for Aquastar. The primary concern at the moment is the adoption of flood prevention measures to prevent a repeat of the November 1988 disaster in southern Thailand in which 12,500 ha of shrimp ponds were flooded and 24 million shrimp lost.

Overdependence on the Japanese Market

Japan has been glutted with supplies from the booming shrimp culture industries of Thailand, the Philippines, and Indonesia. Producers recognize that, as long as Japan remains the primary market for these exporters, prices are unlikely to rise, and they are searching for other markets. The U.S. market, which imports primarily Ecuadorian shrimp and purchases only about 7 percent of Thailand's shrimp exports, has been growing by only 1 percent per year. The European market, however, has been growing at 5 percent per year and recently, according to CP executives, has registered sharp increases over last year's demand, perhaps because of lower prices. If such demand continues to increase, long-term prices might stabilize at around 150 baht ($6.00)/kg.

In the short term, however, the outlook is bleak. Between May and August 1989, prices fluctuated between 120-150 baht ($4.80-$6.00)/kg, but fell again in September to 95-100 baht ($3.80-$4.00). Large shrimp growers, with vertically integrated systems, can remain solvent even at these prices. Aquastar estimates that its current production costs range between 80-100 baht ($3.20-$4.00)/kg, with the prospect of a future decline to 70 baht ($2.80). At the moment, low local prices do not concern the company or its participating members because they are operating on long-term purchase contracts of 146 baht ($5.85)/kg (30 pieces). Initial harvests averaged 4.3 t per pond—well above the expected 3.5 tons. In a move to diversify its foreign markets, Aquastar has already shipped 20 t to Spain, with a second order destined for Canada. Ting Thai, with its relatively cheap land purchases, estimates its costs at about 80 baht ($3.20)/kg. The company is contemplating a switch to fish production should shrimp prices dip lower. CP's costs, which include expensive land purchases, and construction and labor costs, are between 95-100 baht ($3.80-$4.00)/kg. CP is concentrating on mastering intensive shrimp culture technology. The economic picture is more ominous for small-scale growers who must pay higher prices for feed and postlarvae. Mali Boonyaratpalin, Director of NICA, estimates costs for small farmers at 110-117 baht ($4.40-$4.68). With few financial resources, such farmers will not survive long under prolonged low market prices. While some small farmers who own their own land and provide their own labor may be able to scrimp by, mid-level farmers, with higher land and labor costs, may be hit particularly hard. If low

shrimp prices prevail over the next few years, high-tech shrimp farms with high production costs may be saying good-bye to their investments. (Source: IFR-89/95, prepared by Paul E. Niemeier, Foreign Affairs Specialist, Office of International Affairs, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.

The Fisheries of Seychelles

Introduction

Seychelles' commercial fishing industry has seen dramatic development since 1986 and is poised to challenge tourism as the nation's largest revenue earner by the end of the century. Seychelles is at the center of the Indian Ocean tuna fisheries. Fishing Port, in the eastern section of the capital city, Victoria, is the most important tuna landing and transshipment port in the southwestern Indian Ocean. Foreign fleets from France, Spain, the U.S.S.R., Mauritania, and other countries fish for tuna in Seychelles' bountiful waters. The domestic artisanal fleet fills the domestic demand for fish supplies, and provides some export earnings.

But, while Seychelles earns $7 million in licensing fees and transshipment charges, it earns only $2 million from artisanal fishery exports. This amount could be greatly increased with the introduction of a national tuna purse seiner fleet. However, the government finds it difficult to attract young people to the fishing profession despite good income and various incentive programs. The government of the Seychelles is aggressively trying to develop the fisheries sector, including port facilities, infrastructure, processing facilities, and a national commercial tuna fleet. Much of Seychelles fishery development is financed by bilateral and multilateral foreign aid.

The Seychelles, a group of 90 tiny islands scattered over a vast area of the Western Indian Ocean (Fig. 1) gained its independence from the United Kingdom in 1976. The country was basically a one-industry nation until French fishery research vessels started surveying nearby ocean waters in 1980. Tourism was, and remains the most important industry in this beautiful tropical island country, but fishing, especially the tuna fishery, is challenging tourism as the major foreign exchange earner. Victoria, the capital located on Mahe Island, has become a strategic base for tuna fisheries.

The Seychelles islanders are probably the world's greatest consumers of fish per capita at 90 kilos per person each year. The fishing industry directly employs over 1,400 people, 85 percent of them full-time. However, the fisheries sector is controlled by the government, primar-

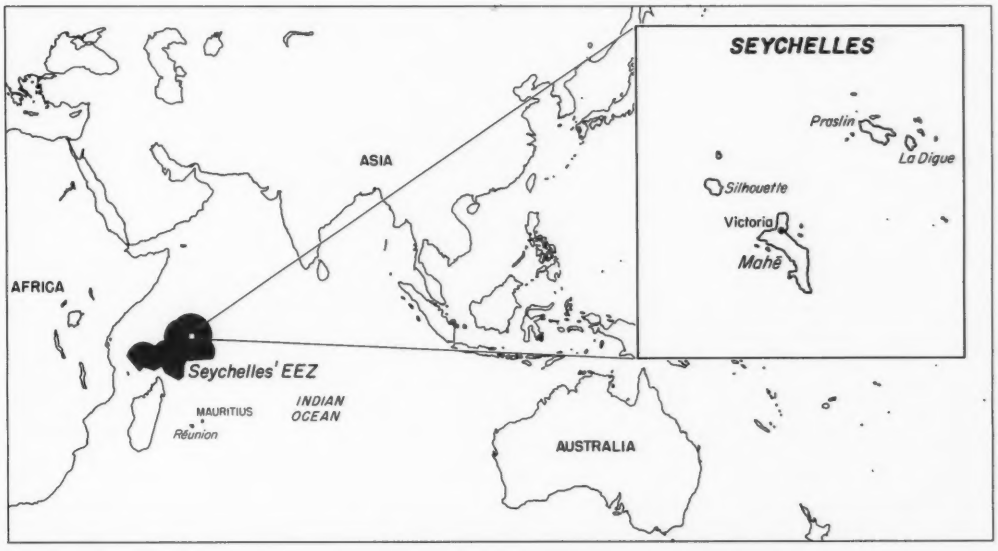


Figure 1.—The Republic of Seychelles, principal islands, and its EEZ.

ily through the Seychelles Fishing Authority (SFA) and the Seychelles Marketing Board (SMB). The government's basic objectives for the fishing industry are to satisfy domestic fisheries consumption, increase fishery exports, obtain additional revenue from foreign fleets operating in Seychelles waters through licensing fees and port services, and develop its own commercial fishing capabilities.

Fishing Grounds

An oasis in the vast Western Indian Ocean, the Republic of the Seychelles lies astride an important tuna migration route. In 1978, the Seychelles declared a 200-mile Exclusive Economic Zone (EEZ) of 1 million square kilometers (Fig. 1), encompassing the world's richest tuna grounds, to protect its resources from far-ranging deep-sea fishing fleets from Japan, Taiwan, the Republic of Korea, and the Soviet Union. The Seychelles' 200-mile EEZ extension truncated part of Mauritius' traditional fishing grounds, but the two countries have worked together to coordinate their fishing regulations. The Government of Seychelles is trying to establish a deep-sea fishing industry based in Fishing Port, a section of the capital, Victoria, and needed to establish authority over its grounds. The only waystation within hundreds of miles, the Seychelles has become an important site for provisions, repairs of vessels, and transshipment of fishery products landed by foreign tuna fleets.

Early in the 1980's, tuna stocks were discovered off the Seychelles. The French tuna industry sent a purse-seiner, the *Ile de sein*, on a 3-month survey, with encouraging results. A 7-month French expedition, begun in December 1981, also had positive findings. At the end of 1982, four vessels previously based at Abidjan, Ivory Coast, started commercial fishing on a trial basis. By the end of 1984, there were 48 French and Spanish tuna vessels fishing in Seychelles waters. Within two years the tuna industry had turned Seychelles' EEZ into a fisheries bonanza, coming in a close second to tourism as a foreign exchange earner.

The main tuna fishing grounds have been east of the Seychelles. However, in 1986 new fishing grounds were discovered. It seems that the tuna move clockwise around the archipelago, converging on Mahe, the largest island. New gounds to the northwest of the islands show promise, depending on the type of fishing practiced. Grounds to the north also abound in tuna at certain times of the year.

The Seychelles Fishing Authority (SFA) decreed that foreign fishing will not be permitted closer than 60 miles from the Seychelles' coast, the approximate extent of the shallow continental shelf. This area is reserved for Seychelles fishermen, who rarely fish in deep waters beyond 60 miles.

Government Administration

The Ministry of National Development, which had oversight and operational responsibility for the fishing industry and the various components which comprise the sector, was abolished in June 1989. In the reorganization, the Ministry of Agriculture and Fishing was created. Although it is not yet clear how Seychelles' fishing activities will be administered in the future, the two dominant organizations will continue to be the Seychelles Marketing Board (SMB). Several other government units are peripherally involved: The Department of Defense assists the SFA in surveillance and control of the EEZ, the Seychelles Development Bank provides the loans for private fishermen, and other government parastatal companies provide handling and maintenance service for the fishing vessels.

The Seychelles Fishing Authority was incorporated in August 1984 by the Seychelles Fishing Authority Establishment Act. The Authority was formed because of the need to develop the fishing industry to its fullest potential. It is a parastatal organization with autonomous legal and financial status, supervised by a Board of Directors appointed by the President. The SFA has responsibility for policy implementation and is charged with assessment and management of fishery resources, regulating all fishing activity, coordination and support of fishing cooperatives and owner-operators, management of ports, development of gear technology, coordination of manpower training, undertaking research, assisting in negotiations with foreign fishing fleets, and coordinating with other agencies with related activities in the fishing area. The SFA is divided into two divisions: Resources and Administration. The SFA is unusual in having multiple functions as a management, planning, development, scientific, and training organization.

The Seychelles Marketing Board controls the local artisanal catch. It buys the catch from fishermen, distributes locally—with the hotels taking the best—and has a monopoly on the export of fresh and frozen fish, most of which goes to Réunion and the EC countries.

Ports and Infrastructure

Since 1982-83 considerable government effort has gone into infrastructure development, which complements and supports the expansion of commercial fishing. Called the East Coast Project, a recently completed large landfill area on Mahe's east coast adjacent to Victoria includes a new fishing port and a range of other marine support facilities, such as cold storage and freezing plants, a tuna cannery, tuna and schooner quays and bunkering areas, a cargo/passenger terminal, and a new processing facility.

Fishing Port is divided into an international and a domestic zone. In the international zone, expanded berthing areas have been completed and bids have been let to increase bunkering capacity. Berth occupancy in 1988 was 93 percent of capacity on average. A U.S. tuna net repair firm, CASAMAR, has started operations in the international zone. In the domestic zone, mechanical workshops, an ice-making plant, and a polystyrene box-making plant are in place or near completion. A new fuel pump for local fishermen began operation in April 1989, financed by the French Government. The U.S. Economic Support Fund (ESF) and the African Development Bank financed the construction of the new SFA headquarters, completed in December 1988. Major work projects in the domestic zone in 1989 include new quays, stores, a service building, ramp, and seawall repair.

Species

Skipjack and yellowfin are the two major species fished in Seychelles' EEZ. Although free-swimming schools consist of as much as 90 percent yellowfin tuna,

the overall average catch for the area is fairly evenly divided between the two species, with skipjack tuna representing 53 percent of the 1988 catch and yellowfin 47 percent. About 40 percent of the yellowfin tuna caught in the Indian Ocean come from the Seychelles' EEZ. Nearly all of the tuna caught in the Seychelles' EEZ is taken by foreign vessels. The Seychelles government plans to acquire its own fleet of tuna purse seiners, and launch a domestic commercial tuna fishery. The first of the new purse seiners was expected to be operational in early 1990.

The cumulative tuna catch inside the Seychelles' EEZ was 220,960 metric tons (t) in 1988, a 36 percent increase over the 1987 catch. The 1988 catch had an estimated world market value of more than US$350 million. Yellowfin tuna represented 47 percent of the total catch, an increase from 38 percent in 1987, while skipjack declined from 62 percent in 1987 to 53 percent in 1988. Most (about 200,000 t) of the tuna catch was transshipped in Victoria (Table 1), making it the most important tuna landing and transshipment port in the Southwest Indian Ocean.

Purse seine landings in the Western Indian Ocean for the first quarter of 1989 were 28 percent higher than those for the same period in 1988, increasing to 60,000 t landed during January to March 1989, compared to 44,000 t in the first quarter of 1988. The catch proportion of skipjack was also unusual for this time of year, when yellowfin is normally the predominant species. The skipjack catch rose 175 percent over the first quarter of 1988. The fishery also moved from its traditional location east of the Seychelles' EEZ to the northwest. As of 30 June 1989, cumulative landings totaled 100,000 t. Average catch rates also reached a record high for the first quarter of 1989, of 26 t per day compared with 18 t for the same period in 1988. Purse seiner catch rates reached an all-time high for this fishery of 37 t per day in March, up from 21 t per day in January.

A tuna cannery, a Seychelles-French joint venture, was opened in 1987 in Fishing Port, Victoria. The joint venture partners are the government of Seychelles (70 percent owners) and two French companies (30 percent): Pêcheurs de France and Armement Coopératif Finistérien (A.C.F.), which own over 40 seiners licensed to fish in Seychelles' waters. The plant is currently operating at 50 percent capacity and in 1988 generated $10 million in earnings. In the last quarter of 1987, the cannery earned more export revenue than all the rest of the industrial sector. During September-December 1987 the cannery exported tuna worth $3 million, while other exports—mainly other frozen fish, copra, and cinnamon—earned only $2 million for the entire year of 1987. Negotiations are taking place to secure access for tuna exports to the U.S. market.

Canned tuna production is expected to reach 23 million cans in 1989, with an export value of about $12.5 million. Actual net return is modest because the raw materials must be imported, including the fish, which is purchased from the foreign tuna vessels. The high demand for raw tuna imports by the canning plant is a contributing factor to the Seychelles' unfavorable trade balance. However, the plant provides direct employment for 300 people, and has other beneficial effects, such as the production of animal feed.

Demersal species are fished only on the artisanal level. Surveys have determined that demersal trawling would not be commercially viable in Seychelles waters. However, other species are receiving attention, and several projects are in various stages of planning and implementation. Crabe giraffe, giant clam aquaculture, and shrimp fisheries are being studied and trial harvests conducted. A trial shark skin curing project is also being carried out.

Fish are the only species of marine life currently exploited to any significant degree. Green and Hawksbill turtles, formerly abundant in Seychelles' waters, have unfortunately been overharvested. Current legislative efforts include limitations or prohibitions on turtle harvesting. Fortunately, the Seychelles does not experience problems with porpoise deaths associated with tuna fishing, which is common in many other areas. Yellowfin tuna do not school under herds of porpoise in that part of the Indian Ocean, so few are caught in purse seine nets.

Types of Fisheries

Foreign Commercial Fleet

As of August 1989, there were 49 purse seiners fishing for tuna under 1-2 year licenses in Seychelles' EEZ (Table 2). This group consists of 20 French vessels, 19 Spanish, 4 Soviet, 3 Mauritanian, 1 Panamanian, and 1 Indian vessel. The French fleet is owned by five separate companies, while the Spanish fleet is owned by two syndicates representing

Table 1.—Seychelles transshipments of tuna caught by foreign purse seiners by species, 1986-88.

	Transhipments (t)				
Year	Yellowfin	Skipjack	Bigeye	Albacore	Total
1986	53,664	70,137	2,843	176	126,820
1987	53,694	80,154	2,868	401	137,117
1988	90,713	106,317	2,921	518	200,469

Table 2.—Purse seiners fishing in the Western Indian Ocean by country, month, and number, 1986-88.

	Number of seiners														
	France			Spain			Mauritius			Others[1]			Total		
Mo.	1986	1987	1988	1986	1987	1988	1986	1987	1988	1986	1987	1988	1986	1987	1988
Jan.	22	19	20	12	12	12	1	1	2	2	1	6	38	33	39
Feb.	22	19	20	12	12	12	1	1	2	2	1	4	38	33	37
Mar.	21	19	20	11	12	10	1	1	2	2	1	2	36	33	33
Apr.	20	15	20	11	11	13	1	2	2	2	1	4	35	31	38
May	20	15	19	11	11	14	1	2	2	2	1	5	34	29	39
June	17	17	17	11	10	15	1	2	2	2	1	5	31	30	38
July	17	17	19	9	10	17	1	2	3	2	1	5	29	30	43
Aug.	19	18	19	10	12	17	1	2	3	2	1	7	32	33	45
Sept.	20	20	20	11	14	18	1	2	3	2	2	6	34	38	46
Oct.	19	20	20	11	15	18	1	2	3	2	5	5	33	41	45
Nov.	19	20	20	11	14	19	1	2	3	2	5	6	33	41	47
Dec.	19	20	20	11	13	20	1	2	3	2	6	6	33	41	48

[1]Includes vessels from Ivory Coast, Panama, United Kingdom, Soviet Union, Japan, and India.

Table 3.—Seychelles transshipments of tuna caught by foreign longliners by country, 1986-88.

Year	Transshipments (t)			
	Korea	Japan	Taiwan	Total
1986	4,149	5,785	1,433	11,367
1987	7,506	5,484	1,109	14,099
1988	8,411	3,131	561	12,103

Table 4.—Seychelles' artisanal fisheries catch by major species, 1982-88.

Species	Catch (t)						
	1982	1983	1984	1985	1986	1987	1988[1]
Jacks	1,177	1,027	1,075	1,429	1,359	1,240	1,737
Snappers, jobfishes	215	374	304	560	908	889	695
Emperors	271	522	329	294	397	308	304
Tuna-like species	966	428	913	547	333	327	300
Indian mackerel	400	241	271	198	35	110	304
Groupers	148	173	129	133	285	247	174
Others	868	1,088	810	929	1,225	832	829
Total	4,045	3,853	3,831	4,090	4,542	3,953	4,343

[1]The estimated species tonnage, given only in percentages, was calculated from the total.

four companies. Both fleets are unionized and the length of time a vessel can remain at sea without making port and crew-relief return trips to their home countries is limited under union contracts. Under the terms of the licenses with the Seychelles government, each purse seiner must employ at least two Seychelles citizens as part of its crew; in 1988, some 130 Seychellois were crewmembers on foreign tuna trawlers. The SFA was negotiating in June 1989 with labor and vessel owner representatives for a new contract for Seychelles fishermen. Licensing fees paid by foreign vessels brought in $4.9 million in fees to the Government in 1988.

Purse seiners had an all-time best year of operation in the southwestern Indian Ocean in 1988. The total foreign catch transshipped (Table 1) from purse seiners through Port Victoria in 1988 was 200,000 t compared to 137,000 t in 1987.

The SFA issues licenses to longliners on a monthly basis. There were 167 foreign longliners licensed to fish in 1988 (127 Korean and 40 Japanese), representing 292 license months. This is a 100 percent increase over the number of longliner licenses issued in 1987 and is attributable to agreements signed with a number of new Japanese companies. Longliner transshipments of tuna for 1988, mostly yellowfin, bigeye, marlin, and shark, were 12,103 t, down 14 percent from 1987. Taiwanese longliners were also active in transshipping though Victoria in 1987, but only 5 Taiwanese longliners used Victoria in 1988 (Table 3).

During 1988, all purse seiners and longliners that called at Port Victoria for either transhipment or bunkering were boarded by inspection officers of the SFA Fisheries Management Section. No violations were detected. Additionally, SFA routinely places observers aboard licensed vessels to monitor fishing activities and to gather biological information. SFA officials state that because almost the entire catch is transshipped via Seychelles' ports on Mahe Island and undergoes inspection in the process, cheating by under-reporting the tuna catch is not a problem.

In 1988, the Seychelles collected $4.9 million in licensing fees, and earned another $1.9 million in transshipment charges. Licensing agreements with the U.S.S.R. with the EC, and with Japanese tuna longlining companies are all subject to renewal in late 1989 and in 1990. In all likelihood, licensing fees will be increased.

Artisanal Sector

Since the islands have been self-sufficient in fishery products for over a century, there is almost no local market for commercial tuna catches. The introduction of the tuna fishery was a welcome export opportunity, but it plays no part in domestic supply. The Seychelles thus does not benefit fully from its tuna resources. The artisanal fleet does not have the technical equipment necessary for commercial tuna fishing.

Before the discovery of tuna stocks, the traditional inshore fishing industry caught over 4,000 t of fish and shellfish per year, sufficient for the country's 60,000 inhabitants. Handlining on the coral grounds around the Mahe and Amirante island groups accounts for 60 percent of all landings. The other major fishing methods are traps (20 percent) and gillnets (10).

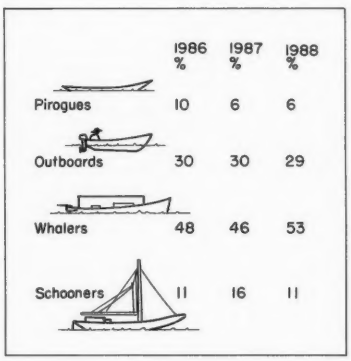


Figure 2.—Seychelles artisanal fleet.

Forty percent of the 1988 artisanal catch consisted of jacks (carangids), 9 percent were jobfish, and 7 percent Indian mackerel (Table 4). Seven percent of the catch was red snapper, down from 12 percent in 1987. The remaining 37 percent of the artisanal catch was composed of various other species. A total of 575 t, about 15 percent of the artisanal catch was exported frozen or fresh in 1988, with 59 percent of it going to Reunion, 10 percent to France and 15 percent to the United Kingdom. Net export earnings from artisanal fisheries were about $2 million.

Some 400 fishing boats on Mahe, Praslin, and La Digue islands make up the major part of Seychelles' artisanal fishing fleet (Fig. 2). Most of the artisanal fleet are 7-9 m "whalers," 5-7 m out-

boards, 9-12 m schooners, and pirogues. Collectively this fleet caught 4,343 t of fish in local waters in 1988, a 10 percent increase over 1987, but still 286 t less than was caught in 1986. "Whalers" accounted for 53 percent of the total artisanal catch, with outboards coming second at 29 percent.

A prototype of a new type of vessel, christened "L'avenir" (the future), built by a private shipyard on Praslin Island, was field-tested in 1988. Two of the new vessels were sold to local fishermen and are having good results. The government plans to acquire its own fleet of tuna purse seiners, the first of which should be operational in early 1990. As a new generation of more cost-efficient, better-equipped vessels with improved living facilities is acquired, the government hopes to attract more young people to the fishing industry.

Although the artisanal fishing reportedly has great potential, the catch has not increased over the past 5 years. One limitation is the small capacity of artisanal crafts. Another limitation is the lack of Seychellois fishermen. Despite the comparatively high level of earnings of artisanal fishermen, young people avoid it because of its unattractive image, long hours, always hard and sometimes dangerous work. Seychelles Polytechnic offers an artisanal fishing program of education, but none of the graduates since 1985 have actually been employed as fishermen. Recognizing the rapidly declining number of fishermen and the need to train young new fishermen, a technical team from Canada was brought to the Polytechnic in May 1989 to develop new and expanded courses.

The government is taking many measures to attract and retain artisanal fishermen, among them a loan program to encourage private ownership of artisanal fishing vessels. In 1988, after screening by the Development Bank and the SFA, 43 fishery loans totaling $456,000 were granted. This compares to only 19 loans in 1987. Loan repayment defaults are a serious problem, attributed in part to the poor management skills of fishermen, and in part to indications of relatively low returns on investment. Efforts are also being made to help established fishermen improve their catch volume though the introduction of modern technology such as echo-sounders and electric fishing reels. Courses on financial management and basic navigation have been given. In addition, fishing income has been made entirely tax-free as an incentive. Nevertheless, enthusiasm for the profession remains low. Fishermen complain about unfair prices offered by the Seychelles Marketing Board's (SMB) Fish Division, and high prices on equipment. Hoping to solve some of the industry's problems, the artisanal fishermen are supporting a proposal for the formation of a fishermen's association.

Exports and Earnings

Artisanal fishery exports generated $2 million in 1988. Most of the 575 t, comprising about 15 percent of the artisanal catch, went to Réunion, France, and the UK. The tuna cannery's exports were worth $3 million in 1988, and were expected to reach $12.5 million in 1989 as it expanded production.

Despite the low level of direct earnings from fishery exports, the fishing industry contributes to revenues in other ways. In 1988, the Seychelles collected $7 million in licensing fees and transshipment charges. Earnings from support services rendered the foreign fleets and profits from the sale of supplies are substantial and will increase as the port facilities expand. The Seychelles' Central Bank reports that the fishing industry and its related activities have created 500 new jobs over the past 18 months. Thus, in the current situation, the Seychelles earns more (over $7 million) from acting as a service and transshipment center than it does from its own exports of fishery products ($5 million).

In fact, Seychelles derives no direct earnings from its valuable tuna resources because it does not have its own commercial fishing fleet. The net revenue from the tuna cannery is quite low, because the joint venture company must import the raw tuna from the foreign fishing companies based in Victoria. Yet, the substantial earnings the Seychelles does enjoy from the fisheries sector have led the government to expand into commercial fishing. A new parastatal company was formed in 1988 to operate a Seychellois fleet of purse seiners which will eventually displace an equal number of foreign vessels currently fishing under license in Seychelles' waters. The first of the 13 vessels constructed in France was to be delivered in 1989. The Canadian technical team brought by the government to the Seychelles Polytechnic to develop a new course to train fishermen in purse seining techniques is part of the commercial fishing development program. The Seychelles hopes through the development of a national commercial fleet to reap benefits from its tuna stocks, as foreign fleets currently do.

Table 5.—Seychelles' exports of fishery products to the United States, by quantity and value, 1983-89.

Year	Quantity (t)	Value (US$)	Major commodities
1983	0.03	1,200	Live turtles
1984	None		
1985	5,384	4,441,000	Skipjack, yellowfin, haddock
1986	2,744	2,435,000	Skipjack tuna
1987	19	192,000	Shrimp
1988	1,206	886,500	Skipjack tuna
1989[1]	5	437,000	Salmon

[1]January-June only

In 1985 and 1986, respectively, the Seychelles exported $4.4 and $2.4 million of tuna to the United States (Table 5). In 1987, only $0.2 million in shrimp and no tuna was exported. In 1988, tuna worth $0.8 million went to the United States, and in the first half of 1989 $0.4 million of salmon. The reasons for these fluctuations in trade are not known, but exports of fishery products may have been redirected to the EC. If the Seychelles is successful in developing its own commercial tuna fishery, exports of tuna to the United States may increase in the future.

International Fishery Relations

Formal fishery agreements have only been concluded with Spain (before its accession to the EC) and the EC. The Seychelles began negotiations with the EC in 1983 for rights to fish within the Seychelles' EEZ. One of the conditions the Seychelles wanted for such an agreement was the construction of port facilities in Victoria, the capital city. Although this condition was not met, a 3-year agreement was concluded on 18 January 1984,

allowing 18 EC tuna freezer vessels to fish off the Seychelles. The EC paid $265,000 per year for tuna catches of up to 6,000 t, along with a fee of $18.50/t of tuna caught. In January 1987, the agreement was renewed for 3 years. It allows a maximum of 40 tuna vessels (22 French and 18 Spanish) to fish in the Seychelles' 200-mile zone. The EC is paying $6 million for this access, as well as $0.7 million for a scientific research program. EC vessels pay $5,000 per year, and $20/t of tuna caught. A Joint EC-Seychelles Committee meeting took place in November 1988 to discuss the implementation and functioning of the current agreement, which expires in January 1990. Renegotiation will take place in the second half of 1989.

In September 1987, the Soviet Union joined the foreign fleets fishing in Seychelles' EEZ. The 1987 agreement granted fishing rights to a maximum of four Soviet purse seiners and two longliners. The Soviet vessels were to give 12 percent of their catch to the Seychelles. Each Soviet vessel was to have at least one observer from the SFA. In addition, the Soviet fleet agreed to land and transship their entire catch and obtain all needed supplies and services in Port Victoria. In October 1988, at the First Session of the Joint Seychelles-U.S.S.R. Fisheries Commission, a 2-year agreement between the Soviet state-owned company, Sovrybflot and the Seychelles government was signed, permitting up to six Soviet purse seiners and unspecified number of longliners.

Vessels from Japan, the Republic of Korea, Mauritius, and the Ivory Coast are allowed to fish within the Seychelles' EEZ. Korea and Japan have refused to sign fishery agreements with the Seychelles because their vessels fish in Seychelles' waters for only a few months each year, as they follow the tuna schools through the Indian Ocean. Japan prefers to have its vessels apply for fishing permits as needed on an individual basis. Japan believes that a more formal agreement would require the payment of unprofitable fees.

Seychelles is a member of various regional commissions organized to monitor and manage tuna stocks and other marine resources and guide national and regional states in commercial tuna fishing. The most important of these is the Indian Ocean Fisheries Commission (IOFC) which also includes the Comoros Islands, Madagascar, Mauritius, and Réunion and others as members. However, the Seychelles is likely to follow its own path of development rather than go in step with group efforts.

Foreign Aid

The Seychelles receives substantial aid to develop its fishing industry. The FAO established a multinational assistance project, coordinated by a Norwegian expert. The most important contributions for the construction of new port facilities and infrastructure at Victoria have been provided by the World Bank, the Kuwait Fund, the Arab Development Bank, and the African Development Bank. The Seychelles is also part of the UNDP/FAO South-West Indian Ocean project for the management and development of fisheries. The U.N. International Development Organization (UNIDO) supervised the establishment of a new boatyard on Praslin. Additionally, funds from a wide variety of sources—including the U.S. Economic Support Fund and the African Development Bank—have been used in fisheries-related development. Also, an energized Indian Ocean Fisheries Commission (IOFC) will provide another source of financial and technical assistance opportunities in the years ahead.

France and the EC have provided considerable financial assistance to the development of Seychelles' fishing industry, and both are expected to continue being heavily involved. A French organization, Orstrom, is the principal consultant for fisheries research for the SFA. Orstrom recently completed studies on yellowfin reproduction and tuna stock assessments. France contributed four pole-and-line vessels for the nucleus of a Seychellois tuna fleet, and part of the infrastructures for the Fish Marketing Board.

A Canadian organization, the International Center for Ocean Development (ICOD) has assisted the Seychelles and other countries in the region on several projects, including EEZ surveillance and training of fishery technicians. The UK provided a large tuna freezing plant in Victoria, and the start of an enforcement program by supplying a deep-sea patrol boat and a surveillance aircraft. Japan has participated in projects involving a tuna survey and the development of artisanal fishing. Japan and Korea sent delegations to the Seychelles to discuss the construction of a quick-freezing storage plant, but the outcome of these discussions is not known. Norway provided funds and expertise in the Victoria port construction project.

Conclusion

There is no doubt that fishing will continue to be a major industry in Seychelles, and may soon rival tourism as the leading sector of the economy. This would be a good use of Seychelles' two most important assets: Its people and its ocean territory. Whether a Seychellois national commercial fishery can be productive and profitable is another matter. Given the enormous distances required to export processed fish—900 miles to Mombasa, 980 to Mauritius, 1,750 to Bombay, and 1,400 to Aden—fishing operations in Seychelles would have to remain at the leading edge of technology to be competitive.

That may be difficult given the lack of a commercial fishing tradition. Yet, Seychelles' commercial fishing endeavors have been remarkably successful to date and there are no reasons why the momentum will not be maintained. If the actual gains in terms of net earnings are still small, future development of the sector looks very promising. (Source: IFR-89/96, prepared by Elaine Samson Yannotti, Foreign Affairs Specialist, Foreign Fisheries Analysis Branch (F/IA23), NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.

The Canadian Salmon Aquaculture Industry

Introduction

Commercial salmon aquaculture in Canada began in 1972 when the first salmon farm was established in British Columbia (B.C.) using surplus eggs from a Canadian Government salmon hatchery. Between 1972 and 1984, however, the industry remained undeveloped and produced only small quantities of salmon; only 107 metric tons (t) of coho and chinook salmon were produced in 1984.

Norwegian fish farmers, however, began to invest in Canada in 1984, and the "gold rush" to establish salmon farms began. Two years later, in 1986, Canada produced 786 t of farmed salmon, only a modest amount in comparison to production in Norway, the United Kingdom, Japan, Chile, Ireland, and the Faroe Islands. However, the stage was being set for the production of salmon to expand rapidly. In 1987, farmed salmon production was worth about C$29 million, or about one-half of the value of total Canadian aquacultural production for that year, and total Canadian production of farmed salmon was projected to reach 23,000 t with an estimated value of over C$150 million by 1990.

Background

Salmon culture is viewed as a benefit to the Canadian economy because fish farms can be located in less populated areas where they can contribute significantly to regional economic development. Additionally, Canada's fisheries are not unlimited, and catches of certain groundfish and shellfish have declined in recent years; fish farming is viewed as an alternative source of high-valued species that does not compete with existing fisheries. The seafood products generated by fish farms generate export earnings when exported, particularly to the United States. These factors have generated support from the Canadian Department of Fisheries and Oceans (DFO), from provincial governments, and from local business interests.

The Canadian salmon culture industry is competitive. Site capacity is not restricted in Canada as it is in Norway; thus the number and the size of salmon pens differ among sites. Multisite farms are common in British Columbia because of the abundance of isolated bays and islands where fish farming can take place. Multisite farming reduces the chance of disease spreading and limits the effects of natural disasters. In Atlantic Canada, in contrast, the growth of multisite farms is not prevalent as there are fewer suitable sites for raising salmon. Atlantic salmon, *Salmo salar*, is raised in Atlantic Canada, but small quantities (less than 2 percent) are also being raised in British Columbia where coho salmon, *Oncorhynchus kisutch*, and chum salmon, *O. keta*, are more popular.

Production of both Atlantic salmon and Pacific salmon on both coasts of Canada has gone from 157 t in 1980 to 1,115 t in 1986. At one time it was thought that production of farmed salmon might reach 30,000 t by 1990, but those estimates now appear too high. It is likely that Canada's production of farmed salmon will reach 23,000 t by 1990, provided the surge in Norwegian farmed salmon does not disrupt world markets in 1989-90. Most of the expansion will occur in British Columbia where production of 20,000 t of farmed salmon is being projected for 1990. Production in Atlantic Canada will grow at a more modest pace and is expected to reach about 3,000 t by 1990 (Table 1, Fig. 1).

The force behind Canada's drive to establish salmon aquaculture on both coasts is the enormous United States market, scarcely a few hundred miles to the south of many Canadian salmon farms. Low transportation costs to the U.S. market guarantee Canadians a very important competitive edge, compared with more efficient Norwegian producers who must fly their salmon across the Atlantic

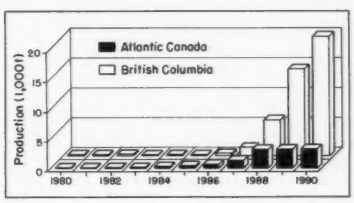


Figure 1.—Canada's farmed salmon production by region, 1980-88, and projected to 1990.

Table 1.—Canada's farmed salmon production by region, quantity, and value, 1980-1986, with projections to 1990.

	British Columbia		Atlantic Canada		Total	
Year	Quantity (t)	Value (C$1,000)	Quantity (t)	Value (C$1,000)	Quantity (t)	Value (C$1,000)
1980	157	898	11	82	168	980
1981	176	985	21	156	197	1,141
1982	273	1,136	38	315	311	1,451
1983	128	708	68	675	196	1,383
1984	107	702	222	2,572	329	3,274
1985	120	820	349	4,197	469	5,017
1986	400	2,728	646	8,078	1,046	10,806
1987	1,362	10,281	1,350	18,415	2,712	28,696
1988	6,000	36,000	3,100	36,300	9,100	72,300
1989	14,500	87,000	3,150	NA	17,650	NA
1990	20,000	NA	3,250	NA	23,250	NA

Ocean to make deliveries. The first exports of farmed salmon to the United States began in 1981; 7 years later, Canadian exports of fresh salmon to the United States amounted to 6,460 t worth $39 million.

Impediments to Expansion

Despite the rapid growth that has taken place in the past few years, Canada's salmon aquaculture industry is limited by 6 important impediments. These include: Availability of smolts, feed supplies, biotechnical expertise, availability of capital, growing public resistance, and economic competition.

Until recently, the Federal Government was the main supplier of smolts to the private sector. These smolts included surplus fish used primarily to enhance or maintain wild stocks. The Canadian Department of Fisheries and Oceans (DFO) decided in the mid-1980's to allow private hatcheries to raise salmon smolts for sale to commercial fish farmers. This allowed the DFO to concentrate on raising smolts for rebuilding wild stocks in both the Pacific and Atlantic Oceans. In 1987 there were 37 hatcheries in B.C., of which about half were owned by salmon farmers. Atlantic salmon farms also face a smolt shortage, but to a lesser degree than Pacific farmers. Privately owned hatcheries in Atlantic Canada supply 80-85 percent of demand. The remainder is provided from excess DFO stocks of "wild" salmon smolts that are bred to survive in the open sea. By contrast, fish farmers prefer a "domesticated" strain of salmon that will adapt and thrive in tightly confined spaces, with thousands of other fish, while feeding on an artificial diet. The ready supply of smolts from private hatcheries is important for future growth in Canada's salmon farming.

The availability of low-cost feed for hungry (and expensive) inventories of fish is a key constraint. Feed is typically the single largest cost facing salmon farmers, and Canadian fish farmers hope to produce 23,000 t of farmed salmon by 1990. It takes about 2 kg of feed to produce a fish that weighs 1 kg. Thus, to reach its 1990 production goal, Canadian fish farmers must have a minimum of 46,000 t of feed. The Canadian aquaculture industry buys its food primarily from local producers and imports the remainder from suppliers in the United States and Europe. Currently there are 3 feed producers in Pacific Canada, two of which are Norwegian owned and one of which is a subsidiary of a U.S. firm. Most of the fish food used in Atlantic Canada is produced locally. Dry feed has been recently introduced to Canadian fish farmers. Abundant stocks of herring and capelin in Canadian waters are an important long-term asset that will benefit Canadian fish farmers in the future. Inexpensive sources of high-protein herring and capelin meal will provide Canadians with an independent supply of inexpensive feed as the cost of feed continues to grow in world markets.

Canadian fishery biologists and scientists have a reputation for excellence which should serve their salmon industry in the future. However, some of the knowledge of nutrition, diagnostics, diseases, and genetics of salmon farming (particularly for Pacific species) is only now evolving in Canada as compared with over 20 years experience in Norway. The Federal DFO undertakes extensive research at biological stations located throughout Canada and is rapidly expanding its ability to provide meaningful support to the industry. In Atlantic Canada the Salmonid Demonstration and Development Farm was established to help local salmon farmers. The farm was part of a 3-year program to study salmon farming in Atlantic Canada, and that project reportedly ended in July 1989. The DFO also has extensive support programs in other areas of aquaculture which help support the salmon farming industry. As the body of scientific data expands, the knowledge will provide Canada with a clear advantage over other salmon producing nations.

The availability of both start-up capital and working capital remains an important constraint limiting the expansion of salmon culture in Canada. The average time that it takes a smolt to grow to market size is 2-3 years. Salmon farmers, thus, do not receive a return on their investment for at least 2 years after beginning operations. Lack of knowledge about fish farming, and uncertainties about future prices for fresh salmon, have made many bankers reluctant to lend prospective farmers money to begin farming, and established farmers funds to maintain their operations. Foreign investment (mostly from Norway and the United States) has provided some assistance, particularly in B.C., but the problem remains.

Aquaculture is meeting resistance from fishermen, homeowners, environmentalists, and other interests who oppose the further expansion. Commercial fishermen, for example, fear that disease may be transmitted from farmed to wild stocks. Sport fishermen are concerned about nets and pens blocking access to local fishing grounds. Homeowners are concerned about the value of their property declining with the influx of fish farms obstructing views and polluting pristine waters. Environmentalists are worried about the accumulation of wastes and the use of chemicals affecting the natural environment. Others are concerned about genetic changes in wild fish if farmed fish escape and breed with wild varieties. Government officials are concerned about the introduction of aquatic parasites that could upset the natural balance of life of the area. Thus, despite rapid growth, problems have arisen which could slow future expansion.

Despite the advantage of close proximity to the U.S. market, Canadian salmon farmers are subject to world-wide competition. World production of salmon has gone from 7,200 t in 1980 to over 200,000 t in less than a decade. The increase in Norway's production of salmon, in particular, has been so sharp that markets will either become saturated or prices will begin to collapse. Canadian fish farmers will have to be able to meet the challenge from Norway as well as the threat from Chile and other countries where lower production costs might undermine Canada's advantages.

Despite these impediments to growth, Canada's farmed salmon industry has shown determination and resiliency in meeting various challenges. This growth follows a two-pronged approach: The rapid, almost "gold-rush" mentality that characterized the development of salmon culture in British Columbia and the more conservative approach (marked by a

moratorium on expansion) that characterized the development of Atlantic Canada's salmon farming industry. Both approaches have encountered problems and both have succeeded, although to a lesser degree than was anticipated only a few years ago when Canadian sources confidently projected salmon production exceeding 30,000 t by 1990.

B.C. Salmon Farming

Salmon farming is the largest revenue producer in British Columbia's aquaculture industry. In 1987, salmon revenues accounted for C$13 million out of total earnings of C$16 million, or 80 percent of the value of aquaculture production that year. Salmon is expected to continue to dominate the B.C. aquaculture industry for the next few years. Oyster production ranks second, followed by farmed trout. As of January 1989, there were 207 salmon farming leases and licenses issued by the Provincial Government of British Columbia, with a total holding capacity of about 58,000 t of fish (44 million m^3 of salmon farm area). However, there were only 105 operating companies farming salmon in the province. The B.C. salmon farming industry is located primarily along the Sunshine Coast, the Campbell River, and the West Coast of Vancouver Island. Production focuses on chinook, *O. tshawytscha*, and coho salmon and Atlantic salmon to a modest degree. Most salmon farmers specialize in the grow-out phase of smolts from hatcheries, but many have recently begun to enter the hatchery business in an attempt to vertically integrate.

Historical

Salmon farming in B.C. started in 1972 when a private venture began raising salmon using surplus eggs obtained from a DFO salmon hatchery. In 1975, four new salmon farms were established, which also obtained surplus salmon eggs from the DFO hatchery. Progress remained slow during this initial period, attracting little interest and producing only small quantities of farmed salmon. In early 1980, the first exports of farmed salmon to the United States began. By 1984, when Norwegian fish farmers (restricted by Norwegian government regulations) began to invest in B.C., there were 10 salmon farms operating in British Columbia. According to the B.C. Ministry of Agriculture and Fisheries, this increased to 37 salmon farms in 1985, 82 farms in 1986, and 118 farms with fish in the water (including 10 with Norwegian investments) in 1987. In 1989, there were 150 operating farms and over 200 holding licenses to operate (Table 2).

Table 2.—British Columbia farmed Pacific salmon production by species, quantity (t), and value (C$1,000), 1980-86, with projections to 1990 and number of salmon farms.

	Coho		Chinook		Other		Total		
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Farm sites
1976	NA[1]	NA	0	0	0	0	1	NA	1
1977	NA	NA	0	0	0	0	7	NA	1
1978	NA	NA	0	0	0	0	13	NA	5
1979	41	157	0	0	0	0	41	157	5
1980	157	898	0	0	0	0	157	898	5
1981	176	985	0	0	0	0	176	985	5
1982	230	908	43	228	0	0	273	1,136	5
1983	73	350	55	358	0	0	128	708	5
1984	64	306	43	396	0	0	107	702	10
1985	66	395	54	425	0	0	120	820	37
1986	304	2,014	87	642	9[2]	72[2]	400[2]	2,728[2]	69
1987	545	3,559	667	5,676	150[2]	1,046[2]	1,362[2]	10,281[2]	118
1988	2,000	NA	3,850	NA	150	NA	6,000	36,000	125
1989	2,700	NA	11,000	NA	800	NA	14,500	87,000	150
1990	2,500	NA	16,500	NA	1,000	NA	20,000	NA	NA

[1]NA = Not available.
[2]Includes rainbow trout.

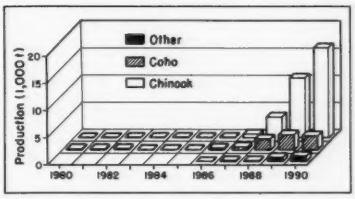
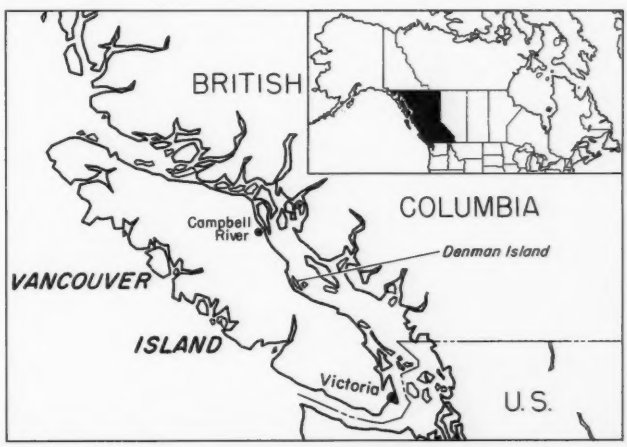


Figure 2.—B.C. farmed salmon production by species, 1980-88 and projected to 1990.

Production

The B.C. Salmon Farmers Association[1] expects farmed salmon production to reach 20,000 t by 1990. The primary species harvested will be chinook salmon (Table 2, Fig. 2). The shift in production from coho to chinook salmon reflects the

[1]Mention of trade names, organizations, or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.



U.S. consumers' preference for larger sizes of fresh salmon. Only small quantities of wild salmon are sold fresh; the majority of farmed salmon are sold fresh. Farmed salmon prices are slightly higher then the wild salmon prices, reflecting the premium paid for freshness and a willingness to pay for fresh salmon when wild salmon are not available. B.C. salmon growers are trying to shift the market to a futures market, where consumers will tell the growers what they want and then the farms will produce to meet demand.

Government Support

Government/industry relations in the B.C. aquaculture industry are notable for the spirit of cooperation that exists. The Provincial Government of British Columbia, with the assistance of the Federal Government of Canada, has established many local and regional assistance programs to assure the safe development of the industry. In September 1988, the B.C. Provincial Government and the Federal Department of Fisheries and Oceans signed a Memorandum of Understanding which: 1) Clarifies Federal and Provincial responsibilities, 2) Streamlines application procedures and reduces administrative and legal burdens on the aquaculture industry, 3) Establishes one-stop leasing mechanisms for commercial aquaculture ventures, and 4) Sets out a cooperative and coordinated approach for government support of industry, including research and development, training, education, leasing and licensing, health, and stock monitoring.

There are also several programs designed to benefit specific, smaller communities. The Community Economic Development Program (CEDP) in B.C. consists of 28 projects established in cooperation with the DFO's Salmonid Enhancement Program. The aim of the program is to increase the population of salmon while fostering local employment. Through the CEDP, Canadians receive training and employment, while enhancing the growth potential of the salmon stock. A primary example of the CEDP initiative is a small salmon hatchery started in Fort Babine, B.C. where unemployment was high. The salmon hatchery now produces over 7,000 individual coho and 2,500 chinook annually, providing a small number of permanent jobs as well as numerous seasonal positions.

Salmon Farmers Association

The B.C. Salmon Farmers Association (BCSFA) was incorporated in 1984 under the Societies Act of British Columbia. It began with nine members, but now represents over 95 percent of all Pacific salmon farmers. The BCSFA has a Board of Directors and a full time staff which implement policies developed by the Board. The major objectives of the BCSFA are to maximize the financial returns to salmon farmers, promote the production of a quality product, and to set and maintain standards to ensure the safe development of the industry. The BCSFA has introduced several programs to assist salmon farmers. These programs include: Egg allocation, broodstock development, disease screening, marketing studies, and education. In May 1989, the Government of British Columbia announced the formation of the British Columbia Aquaculture Research and Development Council (BCARDC). B.C.'s first privately funded salmon research farm, the Ewos Pacific Research Farm was opened on Denman Island on 16 June 1989. The new C$1.5 million facility will examine nutrition, health, and feeding efficiency at the 20-pen farm and its laboratory.

Salmon Farming Industry

There are over 150 salmon farming operations registered in B.C. which include many different individuals and companies. The largest producers of farmed salmon in the B.C. industry include the following firms. Aquarius Sea Farms is the largest producer of farmed salmon in Canada. It was established with Norwegian investment. Aquarius produced about 2,000 t of salmon in 1988. Aquarius opened a processing plant in 1988. Royal Pacific is the first salmon farm to go public on the Vancouver stock market. Public stock is the most viable form of investment, as commercial banks in Canada do not recognize fish farms and their stock as collateral; this might be changed in 1990 if Canadian banking laws are changed.

Pacific Aqua Sea Farms has an interest in both Pacific and Atlantic salmon farming operations. The firm owns several processors and marketers including Tidal Rush Marine Farms (pen-raised salmon) and Deluxe Seafood (producer and marketer), representing the increasing number of firms who find it most profitable to vertically integrate their operations. Hardy Sea Farms is affiliated with Saga Seafoods A/S of Norway. It was founded by Thor Mowinckle after he established the successful A/S Mowi, the leading salmon producer and marketer in Norway. It emphasizes the production of coho and chinook salmon. The Fanny Bay-Rosewall United Hatchery is a hatchery with approximately 100 fiberglass tanks used to raise chinook, coho, and a chinook/coho hybrid called a "conook." Each of the tanks hold about 50,000 smolts. Start-up costs for the hatchery were about C$2 million. Smolts will be ferried from the hatchery to some 120 farms by helicopter. The farm is the first to use a new computer system which allows instant access to water temperatures, oxygen content, and other important data. The General Sea Harvest Corporation was established when the Finnish Sugar Company took control of Sea Aquafarms Ltd. as a majority shareholder. Finnish Sugar is the parent company of EWOS, the large international feed and aquaculture supply firm which supplies much of the B.C. salmon farming industry with feed. The new company owns three hatcheries and fish farms, Tranquil Inlet Marine Farms, Sea Ventures, and Cameleon Aquaculture. The takeover took place in 1989.

The rapid development of the aquaculture industry in B.C. has introduced many problems to the fishing industry. Environmentalists and residents near fish farms complain of improper disposal of fish waste. Many environmentalists and community residents fear that the waste problem is a sign that the industry is growing too fast for safety regulations to keep pace. The Provincial Government recently introduced stiff penalties for fish farmers who violate existing waste disposal regulations. In April 1989, two

companies, Aquarius Sea Farmers and West Shore Ltd., were fined for violating B.C.'s Waste Management Act. The Act prohibits unsafe dumping of waste into the environment. The two firms were charged with dumping dead fish into open pits.

The long-term outlook for salmon farming in B.C. remains excellent. The ability to produce large quantities of chinook and coho salmon will provide Canadian fish farmers with a specialty product that will not compete with the famous Norwegian salmon. B.C. fish farmers, however, are also expected to begin to raise increasing quantities of Atlantic salmon which will provide them with a popular, alternative product. In the near-term, B.C. fish farmers will experience difficulties as market prices for salmon continue to decline as greater quantities of Norwegian farmed salmon enter the market. The U.S. market will continue to dominate B.C. salmon marketing strategies and patterns. It is likely that the demand for salmon will continue to grow in the United States in the next few years, even though prices may decline. Some B.C. fish farmers already expect salmon to become as common as chicken in the diet of American consumers. If this develops, B.C. salmon farmers can anticipate a steady long-term growth.

Salmon Farming in Atlantic Canada

Historical Background

The first experiments with raising Atlantic salmon were carried out in an experimental sea cage operation by the St. Andrew's Biological Station of the DFO in the early 1970's. Salmon farming began in the early 1980's, but it was not until Stolt-Nielson Sea Farms A/S of Norway established a C$2.0 million salmon smolt hatchery near St. George, New Brunswick, that salmon farming began in earnest. The new company, Sea Farms (New Brunswick) was expected to produce 500,000 smolts annually by 1986 providing the region with the potential of harvesting 1,300 t of adult salmon within 2-3 years.

Salmon farmers in Atlantic Canada benefit from the research conducted by the Salmonid Demonstration and Development Farm (SDDF), located at Lime Kiln Bay, New Brunswick, which was opened in 1986. The Development Farm was established with funding from the Fisheries Subsidiary Agreement of the Canada-New Brunswick Economic and Regional Development Agreement. The center is run by an advisory committee of Federal, Provincial, and industrial representatives. The purpose of SDDF was to facilitate the transfer of salmonid sea cage culture technology to the aquaculture industry in the Bay of Fundy. The emphasis was on fish nutrition, salmon genetics research, and the monitoring of commercial salmon cages. The Department of Fisheries and Oceans has also signed Memorandums of Understanding with the various Provincial Governments in Atlantic Canada, similar to the agreement signed with the B.C. Provincial Government. These agreements also outline cooperative approaches to salmon farming in Eastern Canada. This series of agreements establishes a cohesive framework for Federal-Provincial cooperation in all of Canada's salmon growing areas.

Salmon Production

There were 34 firms using 525 sea cages to raise 1.3 million salmon for harvest in 1987-88. The 1987 salmon harvest of 1,400 t, had an estimated value of $15-$17 million. The 1988 harvest of 1,600 t of salmon resulted in a market value of $34 million to $46 million. By 1989, a total of 38 salmon farms were raising Atlantic salmon in the Bay of Fundy region, and that number was expected to increase to 44 farms by the end of the year. By 1990, the value of all salmon aquaculture production in Atlantic Canada was expected to exceed C$100 million.

The "Scotia-Fundy" region is the most important region for salmon farming in Atlantic Canada. This area includes the provinces of Nova Scotia and New Brunswick. Lesser quantities of salmon are being raised in Newfoundland and in Quebec. Figure 3 provides a view of Atlantic Canada's farmed salmon production while Table 3 provides statistical data on this production.

Aquaculture in New Brunswick

New Brunswick is the largest producer of aquaculture products in the Maritime Provinces. In 1987, 32 privately owned farms in New Brunswick produced 1,300 t of Atlantic salmon worth C$18 million.

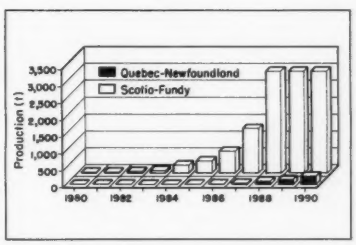


Figure 3.—Atlantic Canada's farmed salmon production, 1980-88 and projected to 1990.

Table 3.—Atlantic Canada's farmed Atlantic salmon production by value (C$1,000), quantity (t), 1979-87, with projections to 1990, and number of salmon farms in the Bay of Fundy, New Brunswick, 1979-1988.

	Scotia-Fundy		Quebec		Newfoundland		Total		No. of salmon farms[1]
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	
1979	6	49	0	0	0	0	6	49	1
1980	11	82	0	0	0	0	11	82	2
1981	21	156	0	0	0	0	21	156	4
1982	38	315	0	0	0	0	38	315	5
1983	68	675	0	0	0	0	68	675	5
1984	222	2,572	0	0	0	0	222	2,572	10
1985	349	4,197	0	0	0	0	349	4,197	20
1986	635	8,078	10	0	1	0	646	8,078	28
1987	1,315	18,415	35	NA[2]	0	0	1,350	18,415	34
1988	3,000	36,300	100	NA	NA	NA	3,100	36,300	34
1989	3,000	NA	150	NA	NA	NA	3,150	NA	NA
1990	3,000	NA	250	NA	NA	NA	3,250	NA	NA

[1]Bay of Fundy only.
[2]NA = Not available.

Forecasts call for production of between 2,800 and 3,200 t worth C$33-43 million in 1988; about twice the levels reached in 1987. By 1990, the aquaculture harvest is expected to generate C$100 million. The New Brunswick industry is dominated by many small farms (average production is 200 t) and two large farms, Connors Brothers and Sea Farms. The lower Bay of Fundy, from Deer Island to Eastport, is dotted with small islands and sheltered bays which are ideal for salmon farming. Upwellings keep water temperatures above freezing in the winter while huge tides sweep waste products away from the cages and keep the waters free from massive algae blooms like those which affected Norwegian farmers in 1987.

The primary markets for New Brunswick farmed salmon are the northeastern United States and central Canada. The New Brunswick aquaculture industry received about 900,500 smolts in 1987. These smolts were supplied by two hatcheries operated by the Federal DFO, the Atlantic Salmon Federation, and 10 private hatcheries. New Brunswick salmon farmers can obtain seed money, salmon smolts, and technical assistance from the Canadian Government. By comparison, Maine salmon farmers must fend for themselves and rely almost exclusively on private initiative.

On 27 February 1988, the Provincial Government implemented the New Brunswick Aquaculture Act. The Provincial Department of Fisheries and Aquaculture was entrusted with the sole responsibility for the promotion of aquaculture, including development of new species. Previously, control of aquaculture was divided among different agencies of the Provincial Government, including those dealing with fisheries, natural resources, energy, and technology. There is a cooperation between the Provincial Government, the salmon farming industry in New Brunswick, and the academic community and private sector. Unlike in B.C., salmon farming in New Brunswick has grown at a very orderly pace. This is due, in part, to the cautious approach taken by Provincial authorities. The New Brunswick Government placed a moratorium on the issuance of farming licenses in 1986 to ensure that the government had time to integrate aquaculture with the traditional fisheries. The moratorium was lifted in the fall of 1988 as projected, but the Provincial Department of Fisheries and Aquaculture is careful about awarding licenses for salmon farms. The net result is that no salmon farms have failed in New Brunswick. Many traditional fishermen in the Bay of Fundy have branched into salmon farming as an additional source of income to supplement a fishery which is not thriving.

There are three major players in the salmon farming industry in New Brunswick: Connors Brothers, Sea Farms, and Atlantic Silver. Connors Brothers is the leading sardine canner in North America and entered the salmon farming industry after it noticed several small salmon farms being established in the area around it's canneries. Besides its salmon farm near its Deer Island cannery, Connors has established a 400,000 smolt hatchery at Lake Utopia and utilized by-product from traditional fish processing operations to set up a new fish meal plant to provide wet feed for salmon. Connors is the largest supplier of fish food to New Brunswick's salmon farming industry. In addition, Connors markets salmon from other farmers. Connors Brothers is owned by George Weston Ltd., a C$11 billion food conglomerate.

Sea Farms is a joint venture between Norway's Sea Farm A/S and Canada Packers, a C$3 billion food distribution company. Sea Farm, which began by selling smolts in Norway and Scotland, now sells smolts and raises salmon. By 1990, the company's hatcheries should be capable of producing more than 1.5 million smolts and 1,000 t of farmed salmon. At present, Sea Farms operates three hatcheries, three marine farms, a processing plant in Maine, and opened a C$1 million processing plant in St. Georges, New Brunswick, in July 1989. The new facility will be able to process and package up to 10 t of fresh farmed salmon each day. The processing facility makes Sea Farm totally integrated, with hatchery, marine farm, and processing.

Atlantic Silver is a marketing cooperative composed of 20 members which was established in 1985. The cooperative markets salmon for its members for a commission of 1-2 percent of the gross sales prices. The fish are sold under the Atlantic Silver label to establish brand loyalty which will be based on the consistently high quality that a consortium can supply. Atlantic Silver members are mostly small farms (100-200 t annually) that dominate the industry in New Brunswick.

Aquaculture in Newfoundland

Salmon culture in Newfoundland consists of two private operations, a provincial demonstration farm and two experimental facilities operated by development associations. They are located in the Bay d'Espoir in southern Newfoundland. The private farms were opened in 1987 and were expected to have their first harvest in the fall of 1988. The two facilities operated by the development associations are involved in experimentation, technological development, and evaluation. The industry is expected to expand in the coming years as there are currently ten applications for new licenses. A Memorandum of Understanding was signed in February 1988, between Federal and Provincial Fishery Ministers. It gave the Newfoundland Department of Fisheries the sole responsibility for licensing fish aquaculture sites and clarified Federal and Provincial roles.

One production problem facing Newfoundland growers is the availability of smolts. Newfoundland does not allow the importation of smolts into the province. Currently there is only one salmon hatchery in the province whose capacity is about 200,000 smolts. The Newfoundland Provincial Government provides smolts to farms, but hopes to decrease that role. Other constraints include ice cover and cold water temperatures which prevent raising salmon in outdoor facilities. Research has been conducted into the possibility of raising salmon in the colder northern water of Newfoundland. The Green Bay Development Association is currently developing an overwintering cage for salmon which would enable fish to be raised in these waters. It received funding from the Provincial Government to conduct tests on a cage made of two

chambers, one for heating the water and the other for holding fish. This would provide fish year round for the association's customers.

Aquaculture in Nova Scotia

Nova Scotia's Atlantic salmon aquaculture industry is much smaller than New Brunswick's. In 1987, there were 10 salmon farms whose total production amounted to only 37 t valued at just under C$300,000. Nova Scotia's salmon farms are located primarily in Cape Breton and along the Eastern Shore of the province. Nova Scotia can boast that it is the home of the largest indoor fish farm in the world. Nova Aqua Smolt Farm, in Glace Bay, N.S., is an established joint venture between Seacoast Fish Farming Ltd. and Norsk Aqua A/S of Bergen, Norway. Nova Aqua has several subsidiaries including, Nova Aqua Smolt, Nova Aqua Sea, and Nova Aqua Salmon.

Aquaculture in Quebec

Salmon culture in Quebec remains a small endeavor which began in 1985, when Baie des Chaleurs Aquaculture Inc. began producing farmed salmon in land-based tanks at St. Omer on the Baie des Chaleurs in the Gaspe Peninsula. The firm began by using sea cages, but the waters in the Baie des Chaleurs freeze during the winter, and in 1986, the firm transferred their stock to 3 silo-type tanks. The firm expected to raise 35 t of salmon in 1987, 100 t in 1988, and 250 t by 1990.

Markets for Canadian Farmed Salmon

Canadian farmed salmon sales are presently limited to the North American market, including restaurants in Toronto and Montreal as well as the huge United States market. Since Canada is the dominant supplier of seafood products to the United States, Canadian farmers enjoy several advantages over their European competitors. These include Canada's familiarity with the U.S. market, as they already have an established market network in the United States. The United States in turn is familiar with Canadian companies, resulting from the long relationship that the two countries have shared. Canadians also have a cost advantage over European competitors in respect to the U.S. market as they enjoy reduced transportation costs and can take advantage of their ability to supply high-quality, fresh salmon on a consistent basis.

Canadian fish farmers see the U.S. market growing by 30,000 t per year, stimulated by a new generation of health-conscious consumers who enjoy low-calorie, low-cholesterol, fresh salmon. The Free Trade Agreement between Canada and the United States is expected to help create new market opportunities in the United States for Canadian farmed salmon. Farm raised salmon receive premium prices when wild salmon is not available; Canadian farmers plan to market their fish November through May before the wild salmon season opens.

Although Canada's best market is the United States, Japan is one of the world's leading importers of salmon, buying high-quality chinook, sockeye, and coho from the wild catch market and some coho from the farmed market. The strong buying power of the yen contributed to higher prices in the fall of 1988. Geographically, B.C.'s location with respect to Japan may provide it with an advantage over Norway. Norway's dominance of the European salmon market, as well as Norway's proximity to the European market makes it too costly for Canadian farmers to enter that market to any significant extent.

In late 1989, it was clear that the increase in Norway's production of farmed salmon had saturated world markets. In response to the growing supplies of salmon reaching the market the Norwegian Fish Farmers Sales Organisation, which regulates Norwegian salmon sales, reduced its minimum price by 16 percent. North American wild salmon freezing and canning companies both witnessed the decline in export sales in Europe as a result of the huge supplies of Norwegian salmon entering the market in the summer of 1989. The outlook for B.C.'s salmon farmers was further complicated by the massive oil spill in Alaska which disrupted (but did not end) the Alaska salmon fishery, and by the strike of B.C. fishermen and processors at the start of the Canadian salmon fishery. The result was an uncertain market.

Future Developments

As the world supply of farmed salmon increases, Canadian farmers will have to become more cost effective. The ability of each farm to survive in the market will depend on its ability to bring relatively low-priced salmon to market. If Canada wants to be an effective player, it will have to capture and maintain a large part of the market now, while it is still growing. It must then maintain that market share into the 1990's when the full effect of the worldwide downward trend on prices will be felt.

Many Canadian fish farmers have realized the need to integrate their operations. Many smaller firms are already being bought out by the larger firms. Smaller farmers (primarily in Atlantic Canada) are using cooperative marketing strategies. The trend towards integration (investing in hatcheries and feed operations) can be seen in British Columbia. Demand for farmed salmon should continue to increase as consumers continue to emphasize nutritious, healthy, tasty, and low-cost seafoods, which will result as production increases. Increased consumption of salmon should result in new value-added forms of salmon. Such products as smoked salmon, marinated salmon, and IQF or fresh fillets and portions will develop new markets for salmon. (Source: IRF-89/99, prepared by William B. Folsom, Foreign Fisheries Analysis Branch (F/IA23), National Marine Fisheries Service, NOAA, Silver Spring, MD 20910.)

The Spanish Market for Squid

Spain is the world's second largest market for squid (behind Japan) and a major player in world squid trade. Spanish annual consumption of squid and other cephalopods was almost 200,000 metric tons (t) in 1987, or about 5 kg per person. To supply this growing market, Spanish fishermen increased their squid catch to a record 80,000 t in 1986, much of it from the rich Falklands area off the coast of Argentina. Even with this record squid catch, however, Spain has been forced to increase its squid imports substantially. Spain imported $170 million worth of squid in 1987, over twice its 1986 imports, making it a net importer of cephalopods for the first time. Spanish squid imports are likely to remain high in the future, but not at the record levels recorded in 1987. Squid imports decreased in 1988.

The Seafood Market

Spain is the world's ninth largest market for edible fishery products. Spaniards consume an average of 1.3 million t of fishery products per year (1984-86), making their market the second largest (behind France) within the European Community (EC). Spain's per capita fisheries consumption increased from about 31 kg per year in the early 1980's to about 34 kg in recent years. Part of this increase can be ascribed to tourism. Spain's warm climate and low prices attract growing numbers of tourists who eat in restaurants where seafood is prominently featured. Popular menu items include broiled hake, paella (seafood and chicken over saffron rice), and grilled shrimp.

Spanish consumers prefer fresh fishery products, which have always been readily available in Spain. Flanked by both the Atlantic and the Mediterranean, Spain has several major ports—Vigo, Bilbao, and Santander in the north, Barcelona in the east, and Cadiz in the south (Fig. 1) and many smaller ports linked to a well-developed distribution system. Fresh fish is available in inland cities as well as on the coast. The largest inland market is Madrid's wholesale food market, Mercamadrid, where large quantities of fresh and frozen fishery products from all over the world change hands daily—leading some Spanish observers to refer to the huge market as Spain's "number one port."

Spain's frozen fisheries market has only recently begun to compete with the larger fresh market. Improvements in marketing and distribution, as well as the growing availability of freezers, led to a 70 percent increase in frozen food consumption from 1983 to 1987. In 1987, Spanish consumers purchased over $230 million worth of frozen fishery products. Hake accounted for 78 percent of frozen sales, while cephalopods (10 percent), crustaceans (6 percent), and soup preparations (6 percent) made up the remainder.

The Squid Market

Spain's consumption of squid and other cephalopods is second only to Japan, and is the highest in Europe. In 1987, Spaniards consumed 194,000 t of squid and other cephalopods, or about 5.0 kg per capita (separate data for squid alone are not available). Squid reaches the consumer in a variety of ways. At fish shops and open markets, squid is sold fresh (local domestic catch) or defrosted. Consumers use it to make deep-fried squid rings or paella, for example. The restaurant and catering trade also provides large quantities of squid to Spaniards and tourists. Battered squid rings are cooked and sold on street corners, squid dishes are served in many bars as appetizers (tapas), and most restaurant menus feature squid.

Although most fishery products in Spain are sold fresh, a growing proportion of squid is sold frozen, much of it prepared for a specific use. For example, Frigorificos Delfin[1], a Spanish wholesale and retail company, sells the following frozen squid products under the

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Figure 1.—The major ports of Spain.

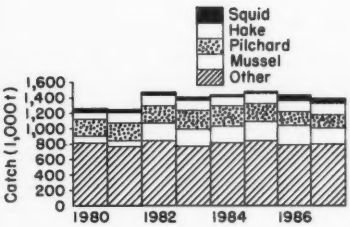


Figure 2.—Spain's domestic fisheries catch by quantity (1,000 t), 1980-87.

Table 1.—Spain's domestic fisheries catch by selected species and quantity, 1980-87.

Species	Catch (1,000 t)							
	1980	1981	1982	1983	1984	1985	1986	1987
Mussel[1]	95.7	78.6	230.4	224.4	216.8	245.7	247.0	206.7
Pilchard	210.1	222.5	216.2	234.2	257.1	229.0	173.2	163.2
Cape Hake	91.5	135.1	139.1	130.4	119.0	136.4	148.0	149.7
Squid[2]	57.8	55.0	48.2	56.1	34.6	34.2	82.7	78.8
Other	809.6	765.3	840.5	767.7	812.9	837.5	783.5	795.0
Total	1,264.7	1,256.5	1,474.2	1,412.8	1,440.4	1,482.8	1,434.4	1,393.4

[1] 1980-1981 FAO figures do not include the Canary Islands mussel catch.
[2] Includes "other squid," bobtail squid, and cuttlefish.

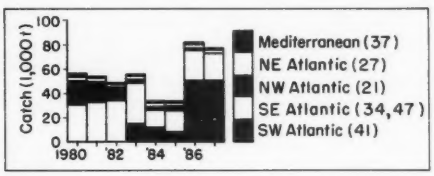
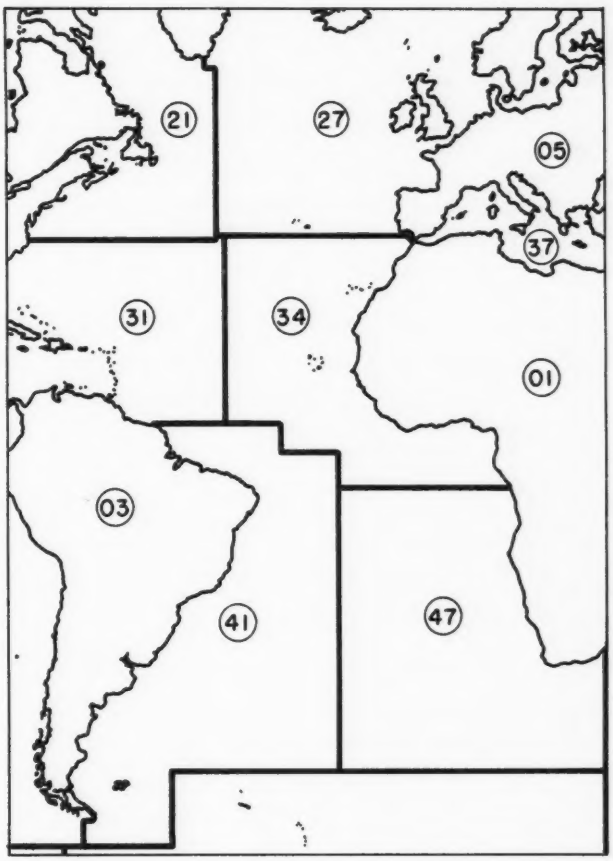


Figure 3.—Spain's squid catch by fishing area, 1980-87.



Delfin brand name: Skinless squid tubes, with or without wings (tubos de calamar); squid rings (anillas de calamar); squid rings in batter (calamares a la romana); and paella ingredients, including squid rings (preparado de paella). Other companies marketing frozen squid products in Spanish supermarkets include Pescanova (Spain's largest frozen food company), Frudesa, Frumar, Krupemar, Findus, and La Cocinera.

Spain's Squid Fishery

Spain's domestic fisheries catch is the eighteenth largest in the world and the second largest in the EC (behind Denmark's); it has averaged about 1.4 million t during the 1980's (Table 1, Fig. 2). The largest harvests, by quantity, are mussels (200,000 t in 1987), pilchards (160,000 t), and Cape hakes (150,000 t). Though squid is Spain's fourth largest fishery, averaging about 80,000 t in 1986-87, it accounts for only 5.6 percent of Spain's very diverse domestic catch. This is a slight increase from the early 1980's, when squid made up 4.6 percent of the total. Spain's squid fishery—both in terms of fishing areas and species caught—has undergone marked changes during the 1980's. Although the squid catch declined during the mid-1980's, it reached record levels by 1986-87.

Fishing Areas

Early in the 1980's, Spain's most important squid fishing areas (Fig. 3) were

the southeast Atlantic (off the coast of Africa) and the northwest Atlantic (off the coast of the United States). From 1980 to 1983, Spain's squid fishery in the northwest Atlantic declined because of the "Americanization" of the U.S. squid fishery. Foreign allocations of squid within the U.S. Exclusive Economic Zone (EEZ) were decreased as the U.S. capacity to fish for squid increased. (There are now more than 10 U.S. freezer-trawlers fishing for squid in the northwest Atlantic.) During 1984-85, Spain's loss of this northwest Atlantic fishery was compounded by another setback. Its squid catch off West Africa (southeast Atlantic) declined, temporarily, because increased fishing by several nations had depleted squid stocks. Thus, in 1984-85, Spain's squid catch was about 40 percent lower than in the early 1980's.

The squid fishery recovered when Spanish fishermen began fishing off the Falklands beginning in 1983. Spain's squid catch in the southwest Atlantic at first roughly equalled its earlier losses in the northwest Atlantic. In 1986-87, however, the Falklands catch surged to over 40,000 t, accounting for half of Spain's squid catch. In 1988, the squid catch around the Falklands increased still further, to an estimated 84,000 t. Meanwhile, the squid fishery off West Africa also recovered.

The future of Spanish squid fishing in its two key fishing areas—the Falklands and the coast of West Africa—depends on two related factors: Squid stocks and fishing agreements. The Falkland Islands Government moved to regulate squid fishing in its 150-mile fisheries zone in early 1988, establishing a license system. Reports indicate that the Government plans to distribute licenses so that Asian and Polish fishing in the zone decrease, while British-Falklands joint ventures and fishing by other EC nations increase. Thus, Spain was able to increase markedly its squid catch in the Falklands zone in 1988. Its 84,000 t catch was 20 percent of the total squid catch in the Falklands fisheries zone. The long-term effect of licensing on Spain's squid fishery is difficult to estimate, however. If squid stocks appear to be overfished (or declining for some other reason such as decreased food supply), fewer fishing licenses will be issued. The Falkland Islands Government considers squid management a delicate task because squid are annual species—the next year's fishery depends directly on the number of squid left to spawn after the current season.

Spain's squid fishery off West Africa is also subject to limitation through licenses. In May 1988, the EC signed a 4-year (1989-92), $300 million fisheries agreement with Morocco. The terms of the agreement, which allows EC vessels to catch regulated quantities of fish and cephalopods, suggest that Spain's squid fishery in this area will decline over the next few years. The cephalopod quota for 1989, most of which was allocated to Spain, was 69,800 t. In subsequent years, however, the quota will decrease sharply, to 33,000 t in 1990 and to 29,500 t per year in 1991-92. Mauritania, which also controls part of the West African squid fishery, currently does not allow EC vessels to fish for squid.

Species

As Spanish squid fishermen have shifted their fishing effort geographically, the composition of Spain's squid catch has also changed (Table 2, Fig. 4). Early in the 1980's, when part of the fishery was concentrated off the east coast of the United States, Spain caught substantial quantities of longfin, *Loligo pealei*, and common squid, *Loligo* spp. From the mid-1980's onward, as Spain instead began fishing around the Falklands, its catch of shortfin squid, *Illex illecebrocus* and *I. argentinus*, and other squids (mainly cuttlefish) has increased. Shortfin squid was earlier regarded as inferior to the longfin variety, but it has gained greater acceptance lately in the Spanish market. In general, as consumers buy increasing quantities of squid in prepared form, either as frozen squid rings or as precooked items, the difference between species seems to become less important.

Spain's Squid Trade

Spain was a net exporter of cephalopods (squid, cuttlefish, and octopus) until 1987. In 1980, for example, Spain imported $85 million worth of cephalopods and exported $112 million. This trend continued even during the mid-1980's, when Spain's cephalopod catch temporarily declined. As recently as 1986, imports were worth $107 million while exports were worth $134 million. In 1987, however, Spain's imports of cephalopods doubled to $221 million while its exports decreased to $118 million, making Spain a net importer of cephalopods for the first

Table 2.—Spain's squid catch by species and quantity, 1980-87.

Species	Squid catch (1,000 t)							
	1980	1981	1982	1983	1984	1985	1986	1987
Longfin squid, *Loligo pealei*	7.6	11.1	8.6	3.3	3.1	3.7	2.1	
Common squid, *Loligo* spp.	10.7	8.4	8.2	7.9	2.8	2.4	2.3	2.4
Northern shortfin squid, *Illex illecebrosus*	14.4	8.3	4.1	0.8	0.3	1.0	0.1	1.1
Argentine shortfin squid, *Illex argentinus*							22.2	22.2
European flying squid, *Todarodes sagittatus*				0.3	1.8	1.0	2.0	1.9
Other[1]	25.1	27.2	27.3	43.8	26.6	26.1	54.0	51.2
Total	57.8	55.0	48.2	56.1	34.6	34.2	82.7	78.8

[1] Includes "other squid," bobtail squid, and cuttlefish (Sepiidae, Sepiolidae).

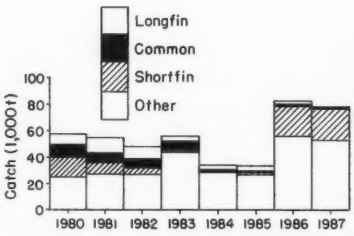


Figure 4.—Spain's squid catch by species and quantity (1,000 t), 1980-87.

time. The surge in cephalopod imports was only part of the dramatic increase in Spain's fishery imports—from $720 million in 1986 to $1,320 million in 1987.

Spain's squid imports have quadrupled during the 1980's, from about 16,000 t in 1980 to over 70,000 t in 1987. Since 1986, when Spain became a member of the EC (and was thus included in detailed EC trade statistics), Spain has been a net importer of squid (Tables 3, 4). In 1986, Spain imported $78 million worth of squid and exported $16 million. In 1987, in line with the increase in total cephalopod imports, squid imports more than doubled to $171 million, while exports increased to only $22 million. If this trend were to continue, Spain's net imports of squid could be expected to increase rapidly in future years. However, though exact data are not yet available, preliminary estimates indicate that squid imports decreased in 1988.

Some observers have suggested that 1987 was an exceptional year for the Spanish squid trade. According to this view, Spanish importers took advantage of large world supplies in 1987 to stockpile frozen shortfin squid. Much of this stockpiled squid was still being sold to processors in 1988, so that import requirements decreased.

Table 3.—Spain's frozen and fresh squid imports by species group and selected countries of origin, showing value (US$1,000) and average price, 1986-87[1].

	1986			1987		
Species[2]	Country of origin	Value	US$/kg	Country of origin	Value	US$/kg
Frozen						
Longfin squid						
	United States	2,867	2.04	United States	357	2.51
	Other	298		Other	122	
	Subtotal	3,165	2.14	Subtotal	479	2.04
Common squid						
	India	1,420	1.39	Morocco	1,017	4.33
	Poland	1,025	0.70	U.K.	977	1.29
	Morocco	753	3.18	United States	617	1.05
	Japan	459	2.30	France	616	1.16
	U.S.S.R.	292	0.70	South Africa	611	1.99
	Other	967		Other	2,905	
	Subtotal	4,916	1.27	Subtotal	6,193	1.71
N. shortfin squid						
	Taiwan	6,205	1.21	U.S.S.R.	27,985	2.00
	U.S.S.R.	5,344	1.38	Poland	26,586	2.52
	Poland	3,907	1.26	Taiwan	25,155	2.13
	Argentina	3,442	1.13	Argentina	15,043	1.44
	Other	6,029		Other	7,684	
	Subtotal	24,927	1.26	Subtotal	102,453	1.99
European flying						
	Norway	2,884	1.85	Singapore	2,267	2.17
	U.S.S.R.	691	0.98	Taiwan	1,114	2.24
	Taiwan	602	1.10	Norway	208	1.51
	Other	155		Other	733	
	Subtotal	4,332	1.48	Subtotal	4,322	2.01
Other						
	Morocco	11,006		Morocco	15,481	
	India	5,211		India	8,647	
	Republic of Korea	3,698		Mauritania	3,020	
	France	2,967		France	2,382	
	Mauritania	1,700		Japan	1,484	
	Other	10,013		Other	17,612	
	Subtotal	34,595		Subtotal	48,626	
Subtotal, frozen		71,935			162,073	
Fresh						
Common						
	France	2,744	3.66	France	3,730	4.48
	U.K.	2,164	3.55	U.K.	1,532	4.79
	Other	866		Other	2,641	
	Subtotal	5,774	3.36	Subtotal	7,903	3.66
European flying		118	1.79		14	1.15
Other		171			599	
Subtotal, fresh		6,063			8,516	
Grand total		77,998			170,589	

[1] Note: Average price per kg is obtained by dividing European Currency Unit (ECU) value of imports by quantity; exchange rates: 1986 U.S.$1 = 1.07 ECU, 1987 U.S.$1 = 0.87 ECU. Prices are not computed for "other" species because of the variety of products in this category.
[2] See Table 2 for scientific names.

Imports

As the preceding discussion makes clear, Spain's market for imported squid is quite volatile, as is world trade in squid. During 1986-87, this volatility was shown not only by the doubling of Spain's squid imports, but also by the shifts in its major suppliers (Table 3, Fig. 5). In 1986, the leading exporter of squid

Figure 5.—Spain's squid imports by country of origin, 1987.

to Spain was Morocco ($12 million), followed by Taiwan and India (each $7 million). In 1987, each of those countries increased its squid exports to Spain, but the leading suppliers were the U.S.S.R. ($28 million) and Poland ($27 million). The U.S.S.R. and Poland, like Spain, recently established important squid fisheries around the Falklands (the U.S.S.R. also catches large quantities of squid in the northwest Pacific). Unlike Spain, however, neither country is a substantial consumer of squid; both are likely to continue to be large squid exporters.

Morocco (and to a lesser extent Mauritania) is an important supplier of "non-Falklands" squid to the Spanish market. Morocco is favoring its domestic squid fishery by decreasing the squid quota allocated to the EC, as mentioned, and has increased its squid exports to Spain. Unlike the three largest suppliers to the Spanish squid market—the U.S.S.R., Poland, and Taiwan—Morocco catches the bulk of its squid within its own territorial waters. Thus, it is less vulnerable to changing license agreements. Furthermore, its squid fishery is ideally located for exports to nearby Spain.

There are three major groups of squid importers in Spain: 1) Trading companies, which buy and sell squid and other fishery products; 2) importers/processors, with processing plants in Spain, the Canary Islands, or abroad, for example Compesca; and 3) importers/processors/fishing fleets, which import to supplement their own catches. Examples of the latter include Pescanova and Frigorificos Delfin. Spanish importers and wholesalers are represented by the Spanish National Association of Seafood Importers and Wholesalers—ALIMAR, in Spanish.

Table 4—Spain's frozen squid exports[1], by species and selected purchasing countries, showing value (US$1,000) and average price, 1986-87[2].

Species[3]	Exports, 1986 Country of origin	Value	US$/kg	Exports, 1987 Country of origin	Value	US$/kg
Longfin squid		261	1.65		523	1.76
Common squid						
	Portugal	5,223	0.72	Portugal	1,979	1.04
	Italy	870	1.22	Italy	1,563	1.53
	Greece	194	1.32	Greece	1,044	1.08
	France	251	1.10	France	889	1.26
	Other	394		Other	342	
	Subtotal	6,932	0.79	Subtotal	5,817	1.05
N. shortfin squid						
	France	3,110	2.13	Japan	3,425	2.36
	Portugal	921	1.11	France	3,323	2.32
	Other	917		Portugal	2,293	1.01
				FRG	553	2.18
	Subtotal	4,948	1.64	Other	819	
				Subtotal	10,413	2.14
European flying squid						
	Italy	481	2.29	Italy	731	3.26
	Other	108		Other	721	
	Subtotal	589	2.26	Subtotal	1,452	2.19
Other						
	Portugal	1,479		Italy	981	
	France	705		Portugal	567	
	Italy	289		France	187	
	Other	654		Other	2,492	
	Subtotal	3,127		Subtotal	4,207	
Grand total		15,857			22,412	

[1] Excludes negligible exports of fresh squid (1986 = $30,000, 1987 = $240,000).
[2] Average price per kg is obtained by dividing European Currency Unit (ECU) value of exports by quantity; exchange rates: 1986 U.S.$1 = 1.07 ECU, 1987 U.S.$1 = 0.87 ECU. Prices are not computed for "other" species because of the variety of products in this category.
[3] See Table 2 for scientific names.

Shortfin squid (pota in Spanish) was the overwhelming favorite of Spanish squid importers in 1987 (Table 3). "Other squid," mostly cuttlefish, have also grown in importance because of their availability in the Falklands. Longfin squid, once the clear favorite, has lost ground and apparently declined in price as other squid species have become more accepted.

Spanish importers prefer squid frozen on board ship (individually quick frozen, or IQF). Both longfin and shortfin squid are most acceptable in 1-2 kg or 5-6 kg packs (in polybags, 2 packs to a master carton). Larger packs (10-15 kg) are also acceptable. Shortfin squid are imported both whole (ungutted) and in tubes, cleaned and uncleaned. Shortfin size gradations are as follows: XX=<14 cmeters long; X=14-18 cm; S=18-23 cm; M=23-28 cm; L=28-33 cm; and XL=>33 cm long. There is a second grading system which applies to longfin and common squid: 6=<8 cm long; 5=8-12 cm; 4=12-16 cm; 3=16-20 cm; 2=20-24 cm; 1=24-27 cm; and 0=>27 cm long. There is reportedly little or no import market for squid rings, retail packs, or value-added products of any kind.

Import licenses are not required for cephalopod products unless they originate from Eastern European countries. However, health and labeling regulations must be followed. Health regulations require that a sanitary certificate issued by the competent authority in the country of origin accompany each shipment. In addition to stating that products have been examined for microbiological and metal content, with the results of each test recorded, the certificate must also contain the following information: Name of product, name of exporter, name of importer, mode of transport, type of packaging, number of packages, and shipment date.

Each individual carton in a shipment must be labelled with the following information in Spanish: Name of importer, country of origin, name of product, ingredients and additives, gross and net weight in grams, date of freezing, latest date on which product may be consumed (18-24 months from freezing date), and

storage and transport instructions (e.g., maintain at −18°C). These regulations for imports into Spain may change. Spain is nearing the end of its 6-year transition period into the EC (ending in 1992), and is adapting its regulations to correspond to those of other EC nations. Several EC nations have proposed standardized Community-wide health regulations modeled after those now in effect in the Federal Republic of Germany.

Exports

Although Spain was a net exporter of cephalopods for much of the 1980's, its exports of squid have been considerably smaller than its imports in 1986-87 (Table 4). In 1986, imports of squid exceeded exports by $60 million. In 1987, when Spanish squid imports were apparently exceptionally large, this difference increased to almost $150 million.

Most of Spain's squid exports are sold to other EC nations, including Portugal, France and Italy (Fig. 6). Spain's membership in the EC is thus a clear advantage for its squid exporters. In 1987, Spain also exported a substantial quantity of squid to Japan, the world's largest squid market.

U.S. Squid Exports

U.S. exports of squid to Spain should be seen in the context of U.S.-Spanish fisheries trade; the figures reflect the fact that fishing is a higher priority industry in Spain. U.S. imports of fishery products from Spain far exceed its exports to that country. For example, in 1986-88, U.S. fishery imports from Spain averaged $42 million per year, while U.S. exports to Spain averaged $5 million per year. Within the EC, Spain is one of the smallest importers of U.S. fishery products.

Though U.S. exports of fishery products are relatively small, squid is a very important component of those exports (Table 5). During the 1980's, squid exports (both shortfin and longfin) have averaged $1.5 million per year, accounting for almost half of the value of U.S. exports to Spain. In 1987, U.S. exports declined to under $1 million when Spain imported large quantities of shortfin squid from the U.S.S.R., Poland, and Taiwan. But in 1988, on the strength of record squid catches by U.S. fishermen, exports surged to over $4 million. These exports must be placed in perspective, however: U.S. imports of squid from Spain have averaged about $1.3 million in 1987-88, actually exceeding U.S. squid exports to Spain in 1987.

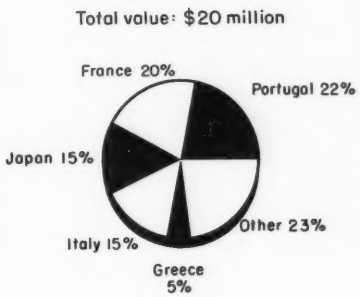


Figure 6.—Spain's squid exports by purchasing country, 1987.

From the point of view of Spanish vessel owners, U.S. squid exports to Spain are somewhat controversial. As mentioned above, Spanish fishermen used to catch substantial quantities of squid in U.S. waters. After the "Americanization" of the squid fishery during 1986-88, some of the influential fishermen's cooperatives in Spain voiced opposition to growing squid imports from the United States. This opposition has continued, though it has not been translated into restrictions on imports of U.S. squid. In 1989, spokesmen from the cooperatives cited imports of "low-quality" squid from the United States as a factor leading to depressed squid prices in Spain (even though imports from other countries are much larger).

Despite opposition from vessel owners, Spanish importers, represented by ALIMAR, consider the United States a prime source of large longfin squid (sizes 0, 1, and 2). Because they are one of the few sources for such squid, U.S. squid exporters can expect continued access to the large Spanish squid market. In general, however, U.S. exporters can expect growing competition from several larger suppliers. A few of these suppliers, such as Poland, devote all of their squid catch to exports since there is almost no domestic market for squid. Others face advantages when exporting to the European Community. Exporters in developing countries such as India, Morocco, and Mauritania pay lower tariffs than do U.S. exporters (cephalopod tariffs are 6-8 percent). In addition, nations such as Morocco and Mauritania face much lower transportation costs when exporting squid to Spain. Thus, U.S. squid exporters are more likely to make inroads into the Spanish market by offering large, high-quality squid rather than attempting to match the low prices of other suppliers. (Source: IFR-89/100, prepared by Brian D. McFeeters, Foreign Fisheries Analysis Branch (F/IA23), National Marine Fisheries Service, NOAA, Silver Spring, MD 20910.)

Table 5.—U.S. squid exports to Spain, compared with total fishery exports to Spain, by value, 1980-88.

	U.S. squid exports (US$1,000)								
Product	1980	1981	1982	1983	1984	1985	1986	1987	1988
Squid									
Longfin, frozen							1,481	100	645
Other, frozen		23	1,103	3,601	480	224	1,599	765	3,668
Canned	10							18	32
Total, Squid	10	23	1,103	3,601	480	224	3,080	883	4,345
Total, Other	3,468	1,413	1,417	713	762	441	1,653	1,994	4,010
Grand total	3,478	1,436	2,520	4,314	1,242	665	4,733	2,877	8,355
Squid as percentage of Grand total	0%	2%	44%	83%	39%	34%	65%	31%	52%

The Fisheries and Fish Trade of India

Introduction

India's seafood exports increased both by quantity and value during the country's 1988 fiscal year (April 1988-March 1989). Although India has begun to diversify fish production and marketing, its efforts to move away from shrimp as the predominant marine export, and Japan as the principal overseas market, have been slow. Because India's coastal shrimp resources have been widely overexploited by both commercial trawlers and small-scale, traditional fishing operations, any future growth in shrimp production must result from the expansion and improvement of shrimp culture operations.

Government policies support trawler construction and favor export-oriented seafood enterprises. So far, however, few non-shrimp-oriented fishing operations have been successful. Meanwhile, the country's seafood processing industry, plagued in the past by the high cost of raw materials and weak domestic demand, remains a virtually untapped area for growth with significant potential for servicing both foreign and domestic markets.

Fishery Exports

India's fishery exports grew nearly 3 percent by quantity in 1988, to almost 99,800 metric tons (t)—the fourth consecutive yearly increase. Export value also increased by 13 percent to almost 6 billion rupees ($387 million at a currency exchange of $1 = 15.5 rupees) (Table 1). India's total fishery catch during this period was a record 3.2 million t. The quantity of Indian seafood exports has grown almost sevenfold since 1961. Although some diversification of seafood markets occurred during 1988, the preponderance of exports, primarily frozen shrimp, still go to two countries: Japan and the United States (Tables 2, 3). The quantity of shrimp exports has risen only 4 percent since 1983. Although frozen shrimp still make up the lion's share of India's seafood exports by quantity (59 percent) and value (79 percent), there has been gradual development of other seafood export commodities, including frozen squid (16 and 6 percent by quantity and value, respectively), lobster tails, and a variety of frozen fish (Tables 4, 5).

Fisheries Production

The localized overexploitation of India's coastal shrimp resources by commercial trawlers and an increasing number of small-scale fishermen has led to the stagnation of India's total shrimp production. The increasing scarcity of shrimp has caused physical clashes among fishermen as larger mechanized trawlers

Table 1.—Indian fisheries exports by quantity, value, percent growth, and unit value, for fiscal years 1984-88[1].

Year	Quantity[2] (t)		Value[2] (million Rs[3])		Unit value Rs/kg
1984	86,187	(−7.0)	384.3	(+3.0)	44.6
1985	83,651	(−2.9)	398.0	(+3.6)	47.6
1986	85,843	(+2.6)	460.7	(+15.8)	53.7
1987	97,179	(+13.2)	531.2	(+15.3)	54.7
1988	99,777	(+2.7)	597.9	(+12.6)	59.9

[1]India's fiscal year runs from 1 April to 31 March of the following year.
[2]Percentage change in growth from the previous year in parentheses.
[3]Rupees. Exchange rate: Rs15.5 = $1.

Table 2.—Indian export markets for frozen shrimp by country, quantity, and percent of India's total export market for shrimp by quantity for fiscal years 1986-88[1].

Country	Export markets 1986 t	1986 %[2]	1987 t	1987 %[2]	1988 t	1988 %[2]
Japan	30,962	(62.9)	32,514	(58.3)	31,696	(55.7)
U.S.A.	10,777	(21.9)	13,214	(23.7)	12,898	(22.7)
W. Eur.	6,466	(13.1)	8,463	(15.2)	10,366	(18.2)
Other	999	(2.0)	1,545	(2.8)	1,875	(3.3)
Total	49,203	(100.0)	55,736	(100.0)	56,835	(100.0)

[1]India's fiscal year runs from 1 April to 31 March of the following year.
[2]Percent of the total export market for shrimp in parentheses.

Table 3.—Indian export markets for frozen shrimp by country, value, percent of India's total export market for shrimp value, and unit value for fiscal years 1986-88[1].

Country	1986 Value[2]		1986 Unit value[3]	1987 Value[2]		1987 Unit value[3]	1988 Value[2]		1988 Unit value[3]
Japan	2,825	(74.7)	91.3	2,925	(68.7)	89.9	3,292	(70.0)	103.9
United States	526	(13.9)	48.8	690	(16.2)	52.2	646	(13.7)	50.1
W. Europe	372	(9.8)	57.5	546	(12.8)	64.5	652	(13.9)	62.9
Others	57	(1.5)	57.0	97	(2.3)	62.8	113	(2.4)	60.5
Total	3,780	(100.0)	76.8	4,258	(100.0)	76.4	4,703	(100.0)	82.8

[1]India's fiscal year runs from 1 April to 31 March of the following year.
[2]Millions of rupees (Rs); exchange rate: Rs15.5 = $1. (Percent of India's total export market for shrimp by value in parentheses.)
[3]Rs/kg.

Table 4.—Indian exports of the fishery products by commodity and quantity for fiscal years 1987-88[1].

Commodity	Exports (t) 1987	1988	Percent change
Frozen shrimp	55,736	56,835	+2.0
Frozen lobster tails	1,863	1,663	−10.5
Frozen cuttlefish/fillets	9,195	8,262	−10.1
Fresh/frozen fish	14,904	11,234	−24.6
Frozen squid	7,621	16,374	+114.9
Dried fish	5,220	3,633	−30.4
Shark fins/fish maws	273	315	+15.4
Others	2,367	1,461	−38.3
Total	97,179	99,777	+2.7

[1]India's fiscal year runs from 1 April to 31 March of the following year.

Table 5.—Indian exports of fishery products by commodity and value for fiscal years 1987-88[1].

Commodity	Export values[2] 1987	1988	Percent change
Frozen shrimp	4,258	4,703	+10.5
Frozen lobster tails	248	236	−4.6
Frozen cuttlefish/fillets	223	234	+5.0
Fresh/frozen fish	302	284	−5.9
Frozen squid	137	381	+177.4
Dried fish	66	44	−33.2
Shark fins/fish maws	48	58	+20.9
Others	30	37	+24.4
Total	5,312	5,977	+12.5

[1]India's fiscal year runs from 1 April to 31 March of the following year.
[2]Millions of rupees; exchange rate: 15.5 rupees = $1.

encroach on shallow coastal areas reserved for smaller, traditional gillnet fishing boats. In addition, shrimp trawling operations have a significant negative impact on other fish species, leading to an estimated 70,000 t of discarded "trash" fish annually. Saturation of the shrimp fishery led the southern Indian state of Kerala to establish the first ban on all coastal shrimp fishing for July-August 1989. To prevent overfishing the Bay of Bengal off Visakhapatnam, the Ministry of Food Processing instituted a ban on "bull trawling" (sweeping the sea bottom with nets). The ban was lifted in September 1989. In addition, falling world prices for shrimp have caused India's seafood exporters to pass the lower prices on to the small-scale fishermen, creating further hardship and generating hard feelings between large-scale and small-scale producers.

Fishing Fleet

There are currently 157 large (>20 m) vessels, almost exclusively trawlers, 200 medium (16-20 m) vessels, and over 2,000 small (10-16 m) mechanized vessels operating in Indian waters. In addition, an estimated 180,000 traditional fishing craft (about 5,000 with outboard motors) ply Indian coastal waters. The Government hopes to add over 300 non-shrimp trawlers (23-28 m) and long-liners under its eighth 5-Year Plan (1990-1995). The stagnation of India's shrimp production, despite the increased number of fishing vessels in operation, has led to serious clashes between the mechanized trawl fleet and traditional gillnet fishing fleet, particularly as the larger vessels move inshore in violation of Government regulations.

Trawler Policy

The Indian Government has decided to permit large domestic industrial enterprises to charter foreign fishing vessels, with a clause stipulating an 80:20 catch share ratio between the foreign and Indian partners, respectively. Indian partners reportedly are opting for the value of the catch, rather than the fish, to avoid marketing difficulties. Although the Government ostensively welcomes the chartering of trawlers, the vessels are prohibited from operating in India's coastal waters. Most foreign charters have found this restriction unacceptable and have withdrawn their trawlers. To encourage Indian ownership of trawlers, the Shipping Credit and Investment Corporation of India, which subsumes programs offered in the past by the Shipping Development Fund Committee and the Trawler Development Support Fund, provides a 33 percent subsidy on the cost of Indian-made hulls and loans at the concessional interest rates for purchasing domestic, as well as foreign-built, trawlers.

Foreign participation in fishing joint ventures is acceptable within the framework of India's "Hundred Percent Export-Oriented Unit" (HEOU) program, which provides a favorable regulatory environment for export industries. For deep-sea fishing, foreign ownership in an HEOU joint venture is restricted to 40 percent; up to 15 percent of the catch of an HEOU venture can be sold domestically. Although no age restriction on fishing vessels exists under Government chartering regulations, current Government joint-venture regulations prohibit ships older than 8 years from being brought into India.

Subsidies

The Indian Government recently eliminated the excise duty waiver allowed on diesel fuel consumed by trawlers, except those involved in HEOU's. (The waiver for HEOU vessels amounts to about 0.25 rupees per liter on diesel fuel and 2.50 rupees on gasoline.) This action was apparently taken in response to complaints by smaller fishing operations of the apparent favoritism toward large mechanized operations. The fishing industry as a whole argues that it should receive fuel at the world price—the same price level enjoyed by qualified export-oriented companies which receive a subsidy from the Indian Government for the difference between the domestic and world price.

Ports and Processing

The port of Cochin handled over half of India's seafood exports by volume in 1988; about 80 percent of India's seafood exports were shipped out of the four major ports of Cochin, Bombay, Madras, and Calcutta. The ports of Madras, Calcutta, and Kandla demonstrated significant growth in seafood exports over fiscal year 1987, while Bombay (although still second with 19 percent of total exports), Goa, and Vizag registered decreases. Smaller ports at Tuticorin, Porbander, and Paradeep each handle at least 1 percent of India's seafood exports.

India's seafood processing sector remains largely dormant and the potential, particularly for the Indian domestic market, untapped. In the past, shrimp canning had been a thriving industry. However, with high raw material and transport costs which rendered Indian processed seafoods uncompetitive in world markets, the canning industry remains an invalid—its failure to focus on the domestic market a key factor behind the seafood industry's difficulties. As a result, most seafood exports depart India frozen and with minimal value-added processing.

Aquaculture

In addition to inland waters, roughly 1.45 million hectares (ha) of coastal land could be brought under aquaculture. About 58,000 ha are currently being utilized for shrimp culture, well over half (35,000 ha) in the state of West Bengal alone. Other Indian states with smaller but notable shrimp farming operations include Kerala (8,000 ha), the newly-created farms in Andhra Pradesh (4,000 ha), Goa (about 4,000 ha), Karnataka (about 3,000 ha), and Orissa (2,000 ha). Industry officials expect that at least 100,000 ha (principly shrimp farms) will be developed within the next few years.

Yields from coastal shrimp farms, usually traditional paddy fields producing one crop of rice and one crop of fish per year, average between 0.5 and 1 t/ha, although a few operations have reached impressive levels of up to 9 t. Shrimp farming specialists believe that with more intensive culture systems, shrimp yields throughout India can consistantly reach 5 t/hectare.

Prospects

The priorities of the Indian seafood industry are four-fold: 1) Diversification of production, 2) diversification of markets,

3) increased food processing, and 4) substantial growth in domestic seafood consumption. Industry experts concede that the country's over-reliance on shrimp (almost 80 percent of its seafood exports) and Japanese and U.S. markets pose dangers for the future. Meanwhile, alternative seafood products such as squid, tuna, cuttlefish, and various bottomfish remain almost totally unexploited by the Indian fishing industry. These fish are not being ignored, however. Fishermen allege widespread poaching by East Asian fishermen and the Indian Navy and Coast Guard have confiscated about 30-40 fishing vessels over the last 3 years.

A number of countries, as well as the UNDP and FAO, have promised assistance for the development of India's fishing sector, and particularly its shrimp farms. Japan has offered the West Bengal State Government 700 million rupees ($45 million) to expand shrimp farms. Thailand, France, and the UNDP also intend to assist in the development of a number of fresh and brackishwater shrimp farms and hatcheries. Australia will provide $50 million in concessional credits to augment India's deep-sea fishing industry.

Some diversification of markets has taken place in recent years. There has been a steady decline in the percentage of seafood exports to Japan as that counry increases its cultured shrimp imports from Indonesia, China, Thailand, Taiwan, and Vietnam. Western European countries have picked up some of the slack for India's exports, particularly in nonshrimp commodities.

India's Central Institute of Fisheries Technology and other groups are seeking ways to expand seafood processing, utilizing the "trash" fish caught with shrimp, going after deep-sea and other nontraditional fish, and generating follow-up growth in domestic Indian seafood consumption—at prices higher than obtainable through exporting. The hurdles include the traditional Indian aversion to frozen and processed seafood (and the seafood processors' subsequent lack of faith in the domestic market), the huge costs of distributing fish in India, the inability to supply processors with fish in quantities to assure cost-competitiveness, and the reluctance of businessmen to invest in non-shrimp operations. (Source: IFR-89/104, prepared by Paul E. Niemeier, Foreign Affairs Specialist, Office of International Affairs, NMFS, NOAA, Silver Spring, MD 20910.)

Publications

Florida Bay, Artificial Reef Symposia Published

Papers and abstracts from the **"Fourth International Conference on Artificial Habitats for Fisheries"** have been published in the *Bulletin of Marine Science*, 44(2):527-1073, William J. Richards, editor. This large number is an impressive reference with reviews and recent work on artificial habitats, their construction, use, and economics; utilization by fishermen, fishes, and other marine life; and their role in mitigating habitat losses from various parts of the world.

Other articles discuss aspects of artificial reef development in the Mediterranean and Adriatic Seas; the current status, recent trends, and future plans for artificial reefs in Japan; a comparison of the accuracy of visual assessment methods for coral reef fishes; and the efficacy of different artificial reef designs in tropical waters. Also included is an interesting debate on responsible artificial reef development. Articles also address aspects of rigs-to-reefs programs in U.S. and North Sea waters, tire reefs, development of epibenthic communities on artificial reefs, and effects of reef deployment on nearby resident fishes.

Abstracts published present work on artificial fish habitats in Guatemala, Lake Erie, Monaco, the U.S. Virgin Islands, Louisiana, and India. Other abstracts discuss estimation of reef productivity, building a coral reef, transplanting kelp in Los Angeles Harbor, artificial habitats in traditional fisheries, and much more. Altogether, the issue is an excellent reference on artificial fish habitat research and development. It costs $35.00 plus $3.00 shipping to non-U.S. addresses (an annual subscription to the *Bulletin* costs $68 for individuals and $155 for institutions) and is available from the BMS Subscription Office, P.O. Box 368, Lawrence, KS 66044.

Issue number 1 of the same volume, 44(1):1-524, of the *BMS* was devoted to the **"Symposium on Florida Bay, a Subtropical Lagoon,"** held 1-5 June 1987, and cosponsored by the U.S. National Park Service's Everglades National Park and the University of Miami's Rosenstiel School of Marine and Atmospheric Science. Over 80 scientists, representing diverse disciplines participated and many contributed to this huge volume on the bay's ecology, management, and research. Most of the bay lies within the Everglades National Park, and this volume is the first compilation of research results for the unique ecosystem. The bay and its resources are threatened by environmental problems that originate well outside its protected borders, and knowledge about its functional processes, as documented by the symposium, may help to protect its natural state.

Many of the contributions deal specifically with the bay's fisheries and aquatic resources, including reports on juve-

nile fishes, ichthyoplankton, and early life history of spotted seatrout and gray snapper. Other articles discuss the areas spiny lobster and mullet, as well as fishery harvests and population dynamics of sea trout, red drum, and gray snapper. Food habits studies of various fishes are presented, as is work on fish movements and spatial distribution.

Other papers address decapod and stomatopod communities there, ecology of mangrove crabs, abundance and productivity of seagrasses and macroalgae, mangrove ecology, etc. Abstracts document studies on stone crab population characteristics, movement of various sport fishes, trammel net efficiency, osprey nesting, geology of the bay, distribution and abundance of pink shrimp within the bay, mollusk distribution in bay sediments, snook harvest and population dynamics, and more. Relatively little has been published on the resources and ecology of Florida Bay which makes this volume an even more useful reference. This is also available from the BMS Subscription Office for $35 plus $3 shipping to non-U.S. addresses.

Marine Toxins, Sulphur, and Natural Products in the Environment

Publication of **"Marine Toxins,"** subtitled "Origin, Structure, and Molecular Pharmacology" and edited by Sherwood Hall and Gary Strichartz, has been announced by the American Chemical Society, 1155 Sixteenth Street, N.W., Washington, DC 20036 as ACS Symposium Series 418. This particular volume brings together results from selected fields of study into one handy reference, with emphasis on the structures and metabolic origin of toxins and the molecular basis for their toxicity. It was developed from the conference at the Marine Biological Laboratory in 1987 entitled "Natural Toxins from Aquatic and Marine Environments."

The toxins are discussed without chemical or taxonomic bias and range from small molecules to proteins; source organisms for them range from bacteria to vertebrates. Traditional structural studies are included, as are discussions of contemporary molecular pharmacology and conformational chemistry. The book is divided into four parts, with Section one, "general considerations," presenting discussions of marine toxins and membrane channels; biosynthesis of red tide toxins; sources, chemistry, and pharmacology of the saxitoxins; the HPLC method applied to PSP research; tetrodotoxins and saxitoxins in marine bacteria (i.e., *Vibrio*, *Alteromonas*, *Plesiomonas*, and *Pseudomonas*); and natural toxins from blue-green algae.

Section two, on polyether toxins in seafood poisoning, includes articles on the molecular basis of ciguatoxin action; detection, metabolism, and pathophysiology of brevetoxins; X-ray crystallographic studies of marine toxins; and effects of maitotoxin on smooth and cardiac muscle. Section three presents perspectives on palytoxin—one of the most potent coronary vasoconstrictors known—including its pharmacological action, antibody production and development of a radioimmunoassay for it, and other pharmacological and toxicological studies. The final section, on peptide toxins, contains a review of the work on conotoxins, the biologically active peptides in cone snail venom; sea anemone polypeptide toxins that affect sodium channels; and chapters on sea snake venom (neurotoxins), the cytolytic peptides found in sea anemones, some natural jellyfish toxins, plus an article on pardaxin, the neurotoxic polypeptide from the Red Sea Moses sole, *Pardachirus marmoratus*, which targets gills and pharynx of aquatic animals and is eyed as a shark repellant.

Some of these toxins may have various pharmaceutical applications; some are of growing public health concern. This volume, presenting such a wide variety of research and reviews, is a useful contribution to many of those concerned with such problems or applications, for it presents or describes the sources of the natural toxins, emphasizing the metabolic pathways responsible for their synthesis. It also addresses the structures of the toxins and the features which determine both the distribution of toxic materials among the organs of intoxicated species and the stability, disposition, and biotransformation of those toxins.

Noted one contributor, "Collaboration among research groups of different disciplines and among those in different regions seems indispensable for further progress in seafood toxin research." This volume should help advance such progress. Hardbound, the 377-page volume includes author, affiliation, and subject indexes, and is available from the ACS Distribution Offices at the headquarters address at $74.95.

Progress in developing safer, more specific pesticides is being made along the lines of utilizing various natural products, including certain marine species or products. Work toward this end is covered in number 380 in the ACS Symposium Series, **"Biologically Active Natural Products,"** edited by Horace G. Cutler of the USDA's Agricultural Research Service. This 31-chapter volume provides reviews and analyses of many biologically active substances that, formulated into a variety of products, could hold promise for "relief from a broad spectrum of agricultural problems." Or, for that matter, some fisheries problems. One chapter, "Protecting crops and wildlife with chitin and chitosan" by M. L. Bade and R. L. Wick, reviews potential utilization of these shellfish wastes to inhibit crop-damaging fungi and nematodes in lieu of using highly toxic pesticides. Another aspect reviewed is the use of chitosan-based biodegradable plastics to prevent some aspects of marine pollution.

Following a personal overview of natural products and their potential uses in agriculture by editor Cutler, chapters discuss the biological and pesticidal activities of avermectins—biologically active products from fungi; production of herbicidal and insecticidal metabolites by soil microorganisms; structural diversity and physiological activity of toxins of phytopathogenic microorganisms; approaches to studying structure/function relationships in naturally occurring cyclic peptides; and tentotoxin as a potential herbicide. Another chapter by J. H. Cardellina, II, relates his investigation of marine algae and invertebrates which

might produce products active against terrestrial plants and insects, and reports isolation of some novel bioactive compounds. In all, the book provides a wealth of information and insights into this rapidly progressing field for chemists and biotechnologists. With author, affiliation, and subject indexes, the hardbound 483-page volume costs $89.95.

"Biogenic Sulfur in the Environment," edited by Eric S. Saltzman and William J. Cooper, number 393 in the ACS Symposium Series, provides a thorough look at the origins and fates of natural sulfur compounds. It also deals specifically with the cycling of biologically produced sulfur throughout both terrestrial and marine environments.

Included is previously unavailable data on the production of dimethyl sulfide by phytoplankton species, along with information on the emission of sulfur from the roots of trees, and an analysis of the role of marine and freshwater bodies in the sulfur cycle. In addition, organosulfur (thiol) formation and metabolism of acrylate and 3-mercaptopropionate in marine sediments are discussed, along with the roles of organisms ranging from common algae to anoxyphotobacteria in the ongoing sulfur cycle.

Following the overview of biogenic sulfur emissions for terrestrial and marine environments, the volume presents several chapters on sulfur emissions and transformation, with reports on the U.S. National Biogenic Sulfur Emissions Inventory, sulfur emissions from Florida wetlands, emissions from higher plants and trees, origin of hydrogen sulfide in freshwater sediments, and sulfur cycling in an acidified lake. Additional chapters review dimethyl sulfide in the oceans, biogeochemical cycling of dimethyl sulfide in marine environments, dimethyl sulfide reproduction in marine phytoplankton, and dimethyl sulfide and (dimethylsulfonio)propionate in European coastal and shelf waters.

Other articles discuss thermodynamics and kinetics of hydrogen sulfide in natural waters, hydrogen sulfides in oxic seawater, microbial metabolism of dimethyl sulfide, decomposition products of DMSP in anoxic marine sediments, and more. Following that are contributions on the distribution and gas-phase and aqueous-phase transformations of sulfur compounds in the atmosphere, including a review of dimethyl sulfide and hydrogen sulfide in marine air. Altogether, the 43 scientific papers in chapter form provide a broad overview of the state-of-the-art in research and knowledge about the sulfur cycle, which is useful in comparing the impacts of human induced sulfur emissions. Included are author, affiliation, and subject indexes, and the 572-page hardbound volume costs $99.95 (U.S. and Canada) and $119.95 elsewhere.

A Handbook on the U.S. Freshwater Invertebrates

Publication of the third edition of **"Freshwater Invertebrates of the United States"** by Robert W. Pennak has been announced by John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158. This thorough volume has been considerably revised, and the author has reviewed more than 5,000 articles on the various species since 1978 in doing so. The result is a fine reference for field biologists and limnologists as well as for advanced students. Besides the extensive updating, the major difference between the second and third editions is that aquatic insects have now been dropped. At that, the book still runs a massive 628 pages. The Author is Emeritus Professor of Biology, University of Colorado, Boulder.

Also mostly new is a well written "introductory essay" which reviews the freshwater environment, origins of the freshwater invertebrate fauna, freshwater emigrants to the sea, and the major distinctions between marine and freshwater invertebrates. The 24 following chapters, ranging from the protozoans to the pelecypods, provide succinct reviews of the various groups' general characteristics, historical notes on early studies of them, foods and feeding, biology, general ecology, reproduction, dispersal and geographical distribution, collecting and preserving, culture (where appropriate), taxonomy, and much more. Each chapter discusses a major animal group and presents an illustrated key for identifying its species or genera. Also included is a selected bibliography for further reading. The volume is very well illustrated, indexed, and an appendix lists various reagents, solutions, and laboratory items mentioned in the text. Hardbound, it costs $42.50.

Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, the *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Cited

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8 × 10 inches, sharply focused glossies of strong contrast. Potential cover photos are welcome, but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 50 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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ISSN 0090-1830

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